EDWIN MAY'S PHILOSOPHY.

BY

JAMES CAMPKIN,

Author of "The Struggles of a Village Lad;" "Poor Joe, the Parish Boy," "No' but and Ne'er Heed," &c., &c.

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PREFACE.

Upon bringing this little work before the public, I cannot fail to express my heartfelt gratitude for the favourable reception with which my last three works have been received, not only in this country, but also in the colonies. After publishing them, I had intended to lay down my pen; but, owing to the numerous letters which I have received from all classes of persons in Great Britain, requesting a second edition of the "Philosophy of Common Things," I determined, before sending it to the press, to re-write it, and to add several chapters of new matter: I have also changed its name from "Philosophy of Common Things" to "Edwin May's Philosophy." My reason for so doing is to prevent mistakes in

ordering the work, as there are several works entitled "Common Things."

In launching this work upon the great ocean of literature, I do it with full confidence that when it is known it will be appreciated; and I trust that the readers of it will enjoy as much pleasure in studying its contents as I have had in writing it. If this wish is realized, the great aim of the author will be fully accomplished.

THE AUTHOR.

2, Kingsland Road,

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Edwin May's Philosophy.

INTRODUCTION.

"How glad I shall be, Edwin, when we have finished that stupid book which papa is now reading to us; I am really getting tired of it; I should like something else,—something more amusing."

"I am surprised to hear you call Natural History stupid. I thought you were so fond of it."

"So I was; but hearing so many hard names that I cannot pronounce, and of which I do not understand the meaning, it really makes me dislike the subject."

"That is your own fault, Em."

"Please don't call me Em, Edwin; remember I am nearly thirteen years old, and to be called Em sounds quite childish."

"What shall I call you, then?" said Edwin, laughing.

"Emily, if you please; it is not so very long

that you should be obliged to drop above half the word every time you call me by my name."

"I was going to say," said Edwin, "that if you were to ask papa to explain the difficult words, I am sure he would with the greatest pleasure."

"Yes, I know he would, but I do not always like to be asking questions; it makes one seem so ignorant."

"I think it is much better to ask questions than remain in ignorance. You must remember that nearly all useful books contain things that want explanation, and often for the want of that the most instructive books are laid aside as dry and unreadable. Perhaps you have some subject in your mind which you would prefer to the one we are now studying."

"I do not know what I should like," said Emily; "anything that is amusing and instructive."

"You must remember," said Edwin, "that papa has more listeners than you and me. You know that mamma often comes in to read with us; and I am sure she is very fond of the book we are now reading; and I very much question whether she would be equally interested with another; and you know it would be selfish to wish to be amused at the sacrifice of another's enjoyment."

"Really, Edwin, you begin to talk almost like papa. I wish I was half as good-natured as you are; you are always thinking of others in preference to yourself; but I am sorry to say that I think

much more of my own pleasures than of other people's."

Such was the conversation carried on between Edwin and Emily May, who were brother and sister. Their father was a man who had seen a great deal of the world, and had gathered with much experience a large amount of useful knowledge, which it was his delight to impart to his son and daughter. He had spent the early part of his life in the army, but, becoming tired of the profession of a soldier, he retired from the army, and returned to his native village, and settled upon a small farm which had been left him by his father. He had seen enough of the world to be aware that there was no place which presented so much happiness as a quiet and peaceful home. His sole cares now rested on the management of his farm and the education of his two children, for which, in many branches of learning, he was well qualified.

Mr. May was not what might be termed a learned man; but, for all that, he had gathered from books and observation a good knowledge of the sciences,—more particularly those upon which the every-day occurrences of life depend. It was this knowledge he wished to impart to his children, but as yet an opportunity had not occurred in which he could follow out his wishes.

"Father," said Edwin, when they were seated at the tea table, the evening after the above conversation, "Emily says she is tired of the book which

we are now reading, and wishes you would introduce some other subject."

"I think we shall finish the book of which she complains this evening, and then I shall feel great pleasure in directing your attention to any new subject that you would like to study."

"What shall it be?" said Edwin.

"I have been thinking," said Mr. May, "of the 'Curiosities of Nature.'"

"I think," said Emily, "I should like it very well, only I am afraid of the hard words. I have never liked those subjects since we heard the professor at the Lecture Hall upon Natural—dear me! I forget what; all I can remember was, that he was very tedious, and used words that nobody understood."

"If that is all the objection you have got to the subject, I think I can explain all the difficult words; so that we shall manage very well. I think I ought to tell you before we commence the subject, that it is not my intention to go deeply into any of the sciences, but to pick from them just sufficient to explain what we have under our notice. My intention is to give you that kind of instruction which may be of use to you every day of your life; also to try to bring your minds to reflect upon the wonders of those little things by which we are, every hour of our lives, surrounded. I feel great confidence in saying that the more you see and know of God's handiwork, the more you will love and adore

Him, and the more thankful you will be for the many blessings He gives you. A knowledge of some of Nature's laws, and seeing how they act upon material things, will put you on your guard against many foolish blunders into which ignorant people are liable to fall.

"To-morrow evening we will commence the subject."

CHAPTER II.

THE TREE.

The tree—Different parts of a tree—The root—How the roots benefit the tree—Why the roots grow crooked—The use of the root being crooked—Why it is so difficult to pull a small root out of the ground—How the roots help to support each other in a storm—The uses of the elasticity of the root — The use of the tap root—The consequences if all roots had been straight—The uses of little stones to the tree—Inorganic matter — Hydrogen —The use of tapering roots—The use of the bark of the root — How moisture is regulated to the tree — The bark of the root is a filter.

"We are now, my children, about to commence the study of those things which we daily see around us, and one which I consider is of great importance; for without that knowledge we cannot pursue our daily callings, except in a more or less imperfect manner.

"The subject to which I intend calling your attention first is plants; and as we proceed in the subject, I hope to show you that there is as much wisdom displayed in their construction, preservation and economy, as in any of the great works of Nature. You have all seen a tree."

"O yes, papa," said Emily, "and, if you like, I can give you a list of them. Let me see, there is——"

"Never mind, Emily, one tree that we can see will serve very well for our illustrations, as most all trees have nearly the same laws to govern their growth and support. You see that elm tree in the field yonder. That will serve our purpose well. Can you tell me, Edwin, how many parts there are in a tree?"

"O yes, papa! there are the roots, the stem, the sap, the bark, the branches, the leaves, and sometimes the blossoms and fruit."

"You are right, my son, and we will examine them all in their turn; and I am much mistaken if we do not find many curious things before we have done with the subject. You mentioned the roots first; can you tell me of what use the roots are to the tree?"

"I think I can, papa," said Edwin. "They hold up the tree, and keep it fast in the earth."

"You are quite right, Edwin, and it is just the answer I expected. But besides holding up the tree the roots have another office. It is through them that part of the nutriment flows which helps to support the tree."

"Yes, papa, I knew that; I have read that in a book."

"Now, we have ascertained that the roots support the tree in two ways; we must now try to ascertain how the roots manage to accomplish their office, that is, hold up the tree, and keep it fast in the ground."

"Why, papa, the roots always do that," said Emily.

"Yes, but how do they do it?"

"I am sure I do not know, I think I have never read that in any book."

"Can you tell me of what shape the root is?"

"It is very crooked," said Emily; "and I always think that a root is one of the ugliest things one can look at."

"I will show you, although the root is not according to your idea of beauty very handsome, yet it could not, according to human conception, have been better shaped for the purposes which Nature intended it to perform. You say, Emily, that the root is crooked; the next question is, what makes it grow crooked?"

"I suppose that Nature ordained that it should grow crooked."

"Yes; but Nature always employs means for the performance of its works. If you examine a root, you will find the end next the plant the largest, and the other end as fine as a thread. It is the office of this thread-like end to enter the ground in search of nutriment for the tree. While performing this office, it comes in contact with small stones and other hard substances. As the root cannot penetrate through these objects, it is obliged to go round them, and in this way a crooked place is formed in the root."

"You have told us, papa, what makes the root

crooked; now, will you tell us the use of its being crooked?"

"Yes, Edwin; I am now coming to that part of the subject. You see this tobacco tube which I hold in my hand, and how easily I can thrust this piece of straight wire backward and forward through it. Now I will bend it in several places in the same manner as the root is bent. Now, with what difficulty I pull it through the tube; in fact, I cannot pull it through with all the force I can use. Just so it is with the root,—its being crooked is one of the causes which renders it so extremely difficult to pull it out of the earth.

"The root has a double advantage to what can be shown with the pipe; for in that not only is the wire crooked, but in the case of the root both the root and pipe in which it lies are crooked. The root has also another advantage. If you examine a root, you will see that it has branches growing out on all sides. Now, the earthen pipe in which the root lies has but just sufficient room for the root; therefore, when we pull at a root, we are trying to pull two things into the same space, or to make two things occupy a space where there is only room for one.

"Thus, you see, it is next to an impossibility to pull even a small plant out of the solid earth without either breaking the root or pulling the earth up with it.

"But there is another wonderful circumstance connected with the root, in the case of tall trees,

which are exposed to the fury of storms and tempests. When a storm comes on, and a great strain is laid upon the roots on the side next the wind, the crooked parts of the root press against the earth, and the earth is thus driven against the next root, and in this way the harder the wind blows the tighter the roots are held in the earth; in fact, in a storm, every root is compelled to assist its neighbour. On the other side of the tree, the roots may be driven a little way; but in doing so they are doing exactly what the roots on the other side of the tree are doing,—helping to hold each other.

"Besides all this, there is another wonderful circumstance belonging to the roots. When the tree is blown a little out of its perpendicular, as is often the case in storms, what is there to bring it back into an erect position? The roots of which we have been speaking can scarcely bring the tree back to its original position. The most wonderful thing of all is, there is a root on purpose to perform this office. It is generally called the tap root, and is generally the largest of all the roots. This root generally descends into the earth about three feet, when it reaches the clay or other substance upon which the soil lies; it then turns, or runs in an horizontal direction, and, like the other roots, helps to nourish the tree. In elm, ash, and large timber trees, this root can scarcely be recognized from the others. In a storm, this root not only helps to hold the tree up; but when it gets out of its erect position

the root, by its elasticity, brings the trunk or stem of the tree again into an erect position. Let us for a moment suppose that all the roots had been straight, how easily would vegetation have been uprooted! Cattle would not have been able to have bitten off the grass, but they would have pulled it out of the earth. The winds, which are the messengers of health to a tree, would then have been the cause of its destruction by uprooting it.

"Thus, you see, my dear children, those little stones, which seem to careless observers as not worthy of notice, are the principal agents which cause the root to grow crooked, and, in all probability, were it not for them we should soon have no vegetation at all."

"Are the roots," said Edwin, "of any other use besides holding up the tree?"

"Yes, my son; and that question brings us to the next part of our subject. It is through the roots that the inorganic matter and the water are admitted."

"What is meant by inorganic matter?" said Emily.

"Inorganic matter is that substance or substances which the tree obtains from the earth."

"How do you know, Papa, that inorganic substances ascend the tree?"

"Because they may be found in it."

"Could Edwin and I find them if we tried?"

"Easily enough; you have only to burn a piece

of wood, and, when you can burn it no more, you have the ashes left. Those ashes are the inorganic matter."

"Is there nothing more goes through the roots but the ashes?" said Edwin.

"Yes, there is the hydrogen."

"What is that, papa?"

"Hydrogen is a very light gas or air, and found very plentifully in water, from which the tree obtains it. I shall explain that more fully when we come to the stem of the tree. I wish to show you how the water or moisture gets into the roots. You are aware that the root is of a tapering shape, and that it is covered with a brown-coloured bark."

"Yes, papa; we have noticed it often."

"The bark of the root is of a porous, or spongy nature, and absorbs the moisture from the earth. When the moisture gets through the bark there are thousands of little mouths all ready to receive it. Now, there is one thing I want you to notice about these mouths, and it will fill you with astonishment. If you wanted to pour water into a very narrow-necked bottle, what is the best-shaped instrument you would use?"

"A funnel."

"Yes; and you can think of nothing better for your purpose. That is just the shape of the little mouths in the roots. The best illustration I can give you of their shape is, when you take a quill to cut it across to make a pen. Which would collect

the most water, supposing the little mouth came to the surface of the root a circle, or in the oblong form I have mentioned?"

"The oblong form," said Edwin.

"Certainly; and another thing, this little mouth is always full, and thus the supply is regulated to the tree. If the weather is very warm, the tree grows faster, and wants more moisture, which is always ready for it. Now, my children, if the root had not been of this tapering form, this beautiful arrangement could not have been formed. Here, again, we may see the wisdom and beauty of the Creator's works."

"It seems to me, papa, that the bark of the root acts as a sort of filter."

"You are right, Emily, it does, and keeps out all coarse matter which would stop up the pores in the tree."

"I think, papa, I read in a book that the moisture only went in at the end of the root. The book said that at the end of every root there was a small sponge-like substance, which absorbed the moisture into the roots."

"I have read the same thing; but, on examining the substance with a microscope, I found that instead of a sponge it was a spike, with which the root was armed, to enable it to thrust its way through the earth."

"Now I understand you, papa; the whole root acts as a sponge instead of the little point at the end."

"Certainly; the bark is the sponge and filter, and prepares the moisture for the use of the tree. Between the bark and the root are innumerable little cisterns which collect the moisture, and attached to each cistern is a small pipe, or pore, as it is termed, which runs the whole way up the tree."

"Did you ever see the pipes, or pores, papa?"

"Yes, and cisterns too."

"Can we see them?"

"Yes; you have only to get a small root, and with a very sharp knife cut a thin slice off, let it dry, and hold it up to the light, and you may see the holes with the naked eye."

"Why, papa, I did not think there had been anything half so wonderful about such a common thing as a root."

"I daresay you did not, Edwin, simply because you had never noticed them, or had your attention drawn to them. I hope to show you, another evening, that the other parts of the tree are equally wonderful. In the meantime, I hope you will think over what I have told you, and do not forget in the wonders that you have seen to forget their Great Author. I trust, my children, that the more you see of the beauties of His works, the more you will be inclined to love and praise Him.

CHAPTER III.

THE SAP.

The pores in the tree—How the sap ascends the pores—Capillary attraction—Water as a carrier in the tree—How the tree obtains hydrogen—How hydrogen may be found in wood—Oxygen causes the sap to ascend the tree—Why rain water causes plants to grow better than river water—Chemical difference between hard and soft wood—Carbon—How the tree absorbs carbon—Why the tree is larger at the base than at the top of the stem—Carbonic acid—How it is formed—The vegetables are composed of waste materials—Leaves and their uses—Why the leaves fall—Why the leaves turn yellow before they fall The sap in winter.

"In our last conversation, I spoke of how the water, or moisture got into the roots; I shall now show you how it gets up the tree, and how it performs its task."

"I have often thought of that, papa, and wondered how the moisture, or sap, could get up the tree."

"I must tell you, first, from the root up to the topmost branches are immense numbers of little pores or pipes; it is up these pores the sap, as we must now call it, ascends. The stem of the tree is full of them, and that is the cause why wood is of a fibrous nature, and is so easy to split. These little

pipes or pores are all in rings, as you may see when a tree is cut across. It is most singular that the nearer you get to the centre of a tree the harder the wood becomes, and the more sound the wood is the smaller the pores are, which makes it appear that, as the tree has become solid, the pores gradually fill themselves up, and cease working. The nearer we go to the bark of the tree, the larger the pores become, and gradually diminish in size where there is less work for them.

"I think I understand you," said Edwin: "in oak trees what is called the heart of the oak is that part where there are no pores."

"You are right, the oak is a good example. Now you understand a little about the pores in wood, I will tell you how the sap gets up the pores. This is a subject that has never been clearly understood by those who have studied the subject; but I will give you my own opinion, and as you get older you may adopt it or refuse it. Most persons say that the sap goes up the tree by what is termed capillary attraction."

"What is meant, papa, by capillary attraction?"

"I will explain it as clearly as I can. If you put a sponge into a basin where there is but little water, the sponge absorbs or drinks it all up; if you put a lump of sugar in a tea-cup, in which there are a few drops of tea, the tea will very quickly run all over the sugar. A very good instance of capillary attraction is to place a towel in a basin of water, the

water will gradually run up the towel and over the side, and gradually on the floor.

"I think I understand you, papa," said Emily; "to use a short term, the tree may be said to absorb it, the same as a sponge."

"Yes, that is what is meant."

"I believe this theory is perfectly correct; but there is another power at work which writers on the subject have overlooked, and which I will explain presently."

"I cannot see, papa, of what use the water really is in the tree."

"I will tell you, Edwin. I want to show you that the water is of twofold use; first, it acts as a carrier, and is continually carrying materials up the pores, which assists to build up the tree.

"Really, papa; how can water carry earthy matter up the tree?"

"Water is composed of little round balls, or globules as they are called; and it is between these globules or balls that the earthy matter rests. Take a glass tumbler and fill it with shot, and then put in some fine sand; you will find that the sand will find its way into the spaces between the shot, and it is in these spaces the water carries the earthy matter up the tree."

"You said, papa, that the water had a twofold office to perform; will you explain its other use?"

"Now, as the water ascends, the tree has need not only of the earthy matter, but it has need of

hydrogen. You remember that I told you that water was composed of oxygen and hydrogen."

"You showed us, papa, when you spoke of the earthy matter, how it could be found in the tree; can you tell us how hydrogen is found in the tree?"

"Certainly. Take a piece of dry wood and burn it, and if it flames there is hydrogen in it; in fact, it is the heat which drives out the hydrogen, and ignites it, and with the aid of the air causes it to flame."

"Why, we may see that every day. Is it hydrogen that causes coal to flame when put on the fire?"

"Yes. In fact, if we had no hydrogen we should have no flame. In all vegetable substances there is hydrogen, and if you can manage to drive it out by heat it will flame. You now understand that, as the sap ascends the tree, part of the water is decomposed; the hydrogen goes to form wood, and the oxygen is set free. Now, the oxygen is a very light gas, lighter than the air we breathe. As soon as it is set at liberty, it naturally strives to escape upwards, driving the sap up as it ascends. It is a remarkable fact, and will explain the theory of the ascent and descent of the sap. Some persons say that the sap ascends and descends. We know that it ascends, and that the oxygen like all gases expands with heat; therefore the sap continues to ascend during the day, and as the air gets cool in the evening and night the oxygen condenses and the sap descends."

"Are we to understand that all the water or sap is decomposed?"

"No, certainly not; only sufficient for the wants of the tree. A great deal of moisture escapes through the leaves. You can try the experiment almost any day you please; but a warm day, when the sun is shining very brightly, will answer best. Take a large glass and set it over a healthy plant, and in a few minutes its sides will be covered with small drops of water."

"I have often observed," said Emily, "how much better plants thrive with rain water compared with those we water with the water from the well."

"Such is the fact; and the way this is accounted for is the water from the well contains a great deal of lime, and other substances, and is generally what is termed hard water. Thus the spaces of hard water are full before the water enters the ground; therefore there is no room for the earthy matter; thus, when the hard water ascends the pores, it takes little or no nourishment for the plant. Rain water is nearly pure when it falls, and is therefore able to absorb those earthy substances which are so needful to the plant. In this we cannot fail to observe the wisdom of the Creator in the arrangements of his works. To a common observer it appears to be a matter of little importance whether plants receive hard or soft water; but, if it rained hard water instead of soft, those soft and invigorating showers

which cause life and vigour to the vegetable world would fall nearly useless."

"Do all trees take in the same amount of hydrogen?"

"No, Emily. Those trees that take in the most hydrogen have always soft wood, and those that take in the most carbon and earthy matter are the hardest."

"How do you know, papa, that there is more hydrogen in soft wood than in hard?"

"Because in soft wood, as willow, deal, &c., there is much more flame, and less ashes, than in such wood as oak or mahogany."

"You just mentioned another substance which is formed in trees. Carbon, I think you called it."

"Yes, that is one of the principal elements, and without it the tree could not exist."

"Does the carbon go through the roots?"

"No. Many persons think that it goes through the leaves; but this, I believe, is a mistake, as I will shortly show you."

"But before you explain it, papa, will you tell us what carbon is."

"The carbon in the tree is mostly called charcoal; that is, a piece of wood out of which, by means of heat, the hydrogen has been driven. If you take a piece of stick, and put it in the fire, it begins to smoke; take it out and look at it, and you will find it black; that is, the hydrogen has been driven out, and the carbon is left."

"If the carbon does not go through the roots, nor through the leaves, how does it get into the tree?"

"That is a question that has never been satisfactorily answered; as I told you, the general idea is that it goes through the leaves. Now, I have shown you clearly that the sap's progress is upwards, and therefore it cannot go that way; if so, the top of the stem of the tree would be the largest. There is no reasonable way to account for carbon getting into the tree, but by the bark. I have every reason to believe that the bark acts with regard to carbon just in the same manner as the bark of the roots acts with the water, that is, it absorbs carbon. I will give you my reasons for it. First, if you cut off a piece of the bark, say a few square inches, that spot from which you have cut the bark ceases to grow; that is, you have cut off the source from which the carbon is derived, while, in a short time, a thick coat of wood has been growing all over the tree, except where the bark was cut off. There is another reason which, I think, is still more forcible; but first I will ask you which is the greatest, the bottom of the stem of the tree or the top. The top, of course; and I think that is the general rule through all trees. If you look at a full-grown timber tree, you will find the stem nearly twenty feet high. Now, if you notice, the higher the stem grows the smaller it is at the top, or where the arms branch

off. Now, this is just what would happen if the carbon was absorbed by the bark."

"How can you prove it, papa?"

"Easily. You remember, when I explained to you that the atmosphere or air was forty-five miles high, that it was denser at the earth's surface than it was a mile high; that is, the air is thicker close to the earth's surface than it is a distance from it."

"Yes, papa, I remember it well, and you also showed us, with a mountain barometer, that the air pressed more heavily upon us in the dining-room than it did in the room above."

"I am glad you remember that fact, as it will help you to understand what I am trying to explain. As the air is denser at the foot of the tree than at its branches, it follows that there must be a greater amount of carbon at the bottom than at the top; and then, if the carbon is absorbed by the bark, the top of the tree must be smaller than the base, for the simple reason that the base of the tree has a more plentiful supply of carbon than the top. There is another reason, also, which leads me to think that the carbon is absorbed through the bark; and that is, the Creator, in all his works, as far as I can ascertain, does nothing in vain. Now, the bark of a tree is always rough, or mostly so, and more particularly near the bottom of the tree, thus showing us that, by the bark being rough, it presents a

greater surface to the atmosphere, which enables it to catch more carbon than it could do if it was smooth. Another thing is shown—that, where the carbon is the most plentiful, the greater surface the tree presents to catch it."

"Now, papa, will you tell us how the carbon gets in the air, as we cannot see it?"

"It is not found in the air in its simple state, but in what is called carbonic acid, or oxygen and carbon."

"How is carbonic acid carried through the air?"

"It is a most wonderful thing that carbon is a solid substance, but, when chemically mixed with oxygen, it becomes a gas. That is to say, the carbon cannot move of itself, but is taken up by its neighbour oxygen, and away it flies through the air till it comes in contact with a tree or plant, when, immediately it is dashed against a tree, a chemical change is formed, the tree attracts it, and the oxygen is again free."

"How is it first formed, papa?" said Edwin.

"All animals that breathe, take in oxygen, and give out carbonic acid; when a fire is burning, large quantities are formed; in fact, wherever animal or vegetable substances are decaying, carbonic acid is forming. We use oxygen in breathing, and, while breathing, we are preparing a substance for the use of the vegetable kingdom. Thus we breathe out a poisonous gas, which the vegetables purify. In this way, how beautifully it is arranged! we breathe

oxygen and give out carbonic acid, and the tree breathes carbon and gives us back the oxygen. Thus, the greater part of the vegetable world is composed of waste materials, as it were; and, as we look at the tree with the eye of a chemist, we can see a wonderful combination of a little earthy matter, a portion of hydrogen and carbon, with the aid of a little water. If we look at it with the eye of a Christian, we cannot fail to see in it the most astonishing revelations of our Almighty Father's power."

"You have not yet told us the use of the leaves."

"I shall now speak of them. Have you any question to ask?"

"Yes, papa; of what use are the leaves to the tree?" said Edwin.

"Those persons who have written upon the subject say that they are to absorb carbonic acid from the atmosphere; but I think that they are for a very different purpose."

"What is your idea of their uses, papa?"

"I think that they are to help to draw the sap up the tree; for we know that it is through them the waste moisture has to pass before it is dispersed in the air."

"How do they assist the moisture to ascend the tree?"

"They are so arranged that, when the sun is shining, the moisture from them is always being evaporated; thus a continual supply is flowing to

the leaves from the trunk, which must assist to keep the sap moving."

"Why do the leaves fall every year?"

"This is another of those wonderful provisions of Nature which we cannot look upon without admiration. At the end of the year, if we examine the leaves, we shall find many of them scarred with hailstones, bitten through with insects, wounded by the winds, and otherwise damaged; so that after one year's wear they are worn out."

"Is that the reason why they fall, papa?"

"No, Emily. In the autumn, as the heat of the sun declines, there is not sufficient heat given to the tree to expand the oxygen in it, and, therefore, the sap cannot reach the leaves. Thus the leaves die for the want of support, and when there comes one sharp frost they fall."

"Why does the frost cause them to fall? as I have noticed that many times."

"You know that cold, like heat, causes fluids to expand. Now, when it freezes, all the little particles of moisture in the leaf are expanded into ice, and, as they expand, they rend the little fibres of the leaves; so that, when the ice is thawed, the leaf has nothing to support it, and the first gentle breeze shakes it down."

Why do the leaves turn yellow before they fall?" said Emily.

"As they decay the hydrogen escapes from them, and, as this takes place, they gradually change

colour—first, yellow; and, as the hydrogen escapes, next brown; and, if you examine them after they fallen a few weeks, you will find them black, thus showing that all that is left is the carbon."

"I have heard, papa, that in winter all the sap goes into the roots. Is that true?"

"No, Edwin. I do not say that the sap does not descend a little; because we know that the cold contracts the oxygen in the pores of the tree, and thus allows the sap to fall, in some small measure. And in this condition the tree remains all the winter."

"But how is it that the tree cannot grow as well in winter as in summer?"

"Because there is not heat enough to cause chemical action in the tree; and therefore the tree is obliged to remain in that state till the weather becomes warm, when the process again commences."

CHAPTER IV.

BLOSSOMS, FRUIT, AND DISTRIBUTION OF SEEDS.

Every plant has a blossom peculiar to itself—Why the flowers are different in colour to the leaves—Why flowers give out an odour—The uses of colour and odour to flowers —The pollen or dust of one blossom inoculates another— How flowers in nature are inoculated—The uses of bees and butterflies to flowers—Why fruit blossoms are injured by frost—Blight—Its causes—How fruit is preserved till its seeds are ripe—How apples, plums, walnuts are preserved—How trees are transplanted by nature—The uses of squirrels.

"I HAVE often looked at the blossoms of trees; and it has often struck me as wonderful that they should always be of a different colour to the leaves."

"You are right, Emily; and nearly every species of tree has a blossom peculiar to itself."

"The blossoms of some plants have pleasant odours," said Edwin, "as the honeysuckle, the rose, the pink, and many others. Can you tell us why the rose is red and the leaves are green?"

"Because they are made of slightly different materials. All flowers contain a little more hydrogen than the leaves, and it is only for that reason that we can account for the fact. With regard to the first part of your question, why some flowers give out a pleasant odour, I think we may account

for that in this way. You know that all plants use certain materials for their sustenance; some use more of one material than another, and what is not used, or the waste matter, goes out through the leaves. Let us take, for instance, the sweetbriar. There is every reason to believe that the sweet odour that it gives out is nothing more than the waste matter which it is throwing off. In the rose bush, the matter is only thrown off through the flower, and is, no doubt, the refuse of what the flower is composed of."

"Then, papa," said Edwin, "you think the odour of flowers and plants is produced when the plant is throwing off its waste material?"

"Yes, Edwin. If you notice, after a shower of rain the odour of plants is always the most powerful. Thus, you see, when the process of vegetation is the most rapid the odour is the most powerful."

"Do you think, papa," said Emily, "that the colour and odour of flowers are of any real use to them?"

"Yes; if it was not for both their colour and smell, millions of them would not come to perfection, or bear fruit. All blossoms are, to use a gardener's phrase, either a male or female blossom, and it is the female blossom that brings forth fruit; but, unless the fruit blossom comes in contact with the pollen, or dust, of the male blossoms, the others will not produce fruit."

"I have heard that before, and I never could

understand how the dust from one blossom could be conveyed to another."

"In that we have one of those wonderful contrivances of Nature. In every blossom there is lying at the bottom a small drop of honey, which is much coveted by insects, particularly bees and butterflies. Now, if you examine a bee's neck, there is a sort of hairy collar, which gets full of this pollen; and, as the bee thrusts its head down into the flower, this dust shakes off, and thus the blossoms get inoculated, as it is termed. We can now answer your questions of what uses are colour and smell to the flowers. If all the blossoms had been of the same colour as the leaves, the insects would have had a difficulty in finding them; but, as it is, they have two senses to direct them,—sight and smell."

"I have always thought that bees were only for collecting honey."

"Instinct directs them to do that, for their own preservation in winter; but, while they are doing it, they are performing a work which is of inestimable value. The butterflies and bees are some of our most useful insects; in fact, if it was not for their services we should have no fruits whatever."

"Are there any other insects that perform this kind of work, besides bees and butterflies?"

"Yes; myriads of flies and gnats are all intent on obtaining that drop of honey, and at the same time they cannot do it without inoculating the flowers as they fly from one to another."

"Really, papa, I did not think that butterflies were of any use, except for us to admire."

"I dare say not; but there is not a beast, bird, or insect, but has its mission from the Creator, and knows, by its instincts, what its duties are."

"I remember last year, papa, that all the gooseberry bushes were full of blossom, and yet we had no fruit. How can you account for that?"

"I remember it, Edwin, quité well. One night there came a severe frost, and cut them off."

"Yes, papa, I know that; but how is it that the frost cuts them off?"

"I think I have told you that when water freezes it expands. Now, these little blossoms are full of moisture, which, when frozen into ice, expand, and burst the vessels which hold it, and thus the little pores of the flowers are torn to pieces, and can no longer get sustenance from the tree, and they die."

"What is meant by a blight?"

"A blight is very often caused by the north-east winds; and as these winds come from cold and frozen regions, the winds are very cold, which stops the process of vegetation, and then the blossoms die."

"I think we have now done with the blossoms, and must come to the fruit. I cannot tell you the cause of the fruit, or what produces it, further than in most trees and plants it is to propagate its species."

"I have often noticed," said Emily, "how

wonderfully the seeds of trees and shrubs are preserved till the seed is ripe."

"Yes; let us take an apple as an instance. As soon as it is formed it has a very sour and unpleasant taste,—so unpleasant, that nothing will eat it. This sour taste lasts till the seeds or pips are ripe; and when they are nearly ripe the taste of the apple changes from sour to sweet, and is then most pleasant eating. If we examine a ripe apple, we shall find the pips encased in a sort of horny case, which is, for the most part, thrown away when the apple is eaten."

"I have also noticed that the pips have a very unpleasant, bitter taste."

"Yes; and it is that unpleasant taste that prevents us eating them, and thus the seed is preserved."

"I think nearly all fruit is unpleasant before it is ripe."

"Yes; look at the plum. What is more unpleasant to the taste than unripe plums? This is one of those wise arrangements of nature to preserve the seeds of trees. If the young fruit had a pleasant taste, myriads of flies and birds would be ready to prey upon them, and thus the seed of future trees would be destroyed."

"I have often noticed how wonderfully the walnut is preserved."

"Yes, Emily; the walnut itself, from its first formation, is very sweet and pleasant to the taste,

and were it not well protected it would soon be devoured. In the first place there is the outside husk, which has a most unpleasant taste; even if an insect could bore through that, it comes to a hard shell which would entirely hinder it from getting at the kernel. There is another thing which protects the fruit till it is ripe, and that is its colour: when unripe it is of the same colour as the leaves, but as it ripens it changes the colour to yellow, brown, or black. This would lead us to suppose that it was an arrangement of nature, so that the colour might not attract the notice of birds and insects so that they might feast upon them before they were ripe."

"It is a most wonderful thing that the sour apple as it ripens should change to sweet. You see it is the very opposite."

"Yes; a chemical change gradually takes place, and changes the acid to sugar, or to saccharine matter, as they call it."

"I have often noticed when we have walked through the wood yonder, what a number of different sorts of trees we may see,—here an oak, there a blackthorn, whitethorn, hazel, a crab-tree, and many others. I have often wondered how they came there at first."

"It is plain to you, Emily, that man did not plant them, or they would have been planted with more regularity. The crab-tree has very likely been planted by a hedgehog, who is very fond of crabs, but will not eat the pips; these he has left, the foot

of an animal may have pressed it into the ground, and so it has taken root, and grown into a tree."

"Nearly all over this neighbourhood there are large oak trees, and it always seems to me that where we find one oak tree there are large numbers."

"Yes, such is the fact; and nearly all those trees have at some period been planted by the squirrels. In autumn, when the acorns, beech-nuts, and hazel-nuts are ripe, then it is that the little creature makes itself so useful; it is then it performs the great mission for which it was created. For weeks the little creature may be seen climbing and skipping from one bough to another, selecting the ripest acorn or hazel-nut, which it brings down with the utmost care, and takes it to a little distance, scratches a hole in the ground, and buries it. When all the nuts are fallen, it does not cease its labours, but continues to select the best nuts that lie upon the ground, and takes them one at a time and buries them. In this manner it will employ itself till the cold weather sets in, when it will take itself to its nest, curl itself up, and sleep soundly till the winter storms have passed away, when it wakes up lean and hungry, and begins to crop the young branches of the trees. It is said that the squirrel does much harm to the trees. Even if he does eat the young shoots, we ought not to persecute him, but remember if it was not for his services we should not have so many trees as we have."

"It is a wonder, papa, that there are not many more oaks or nut-bearing trees than there are."

"So there would be, if it was not for another of our much-persecuted animals."

"What is that, papa?"

"The wild rabbit. At first sight we are almost inclined to suppose that this little animal was sent only to be the food of man, but the Great Creator has given it its proper sphere and labours to perform. We have just said that the squirrel plants the nut-bearing trees. In time, these all spring up, and would become so thick as to choke all others, if it were not for the wild rabbits, whose food they become. Thus the wild rabbit is sent to thin the trees which the squirrel has planted."

"Are there any other animals which help to distribute plants?"

"Yes, Edwin. The blackbird is fond of sloes, and haws, but after it has eaten them it is only the pulps that digest; the stones or seeds pass through them unharmed, and are carried, perhaps, miles from where they grew. The sparrows are very fond of ripe gooseberries and currants, but their digestion is not strong enough to digest the seeds, and therefore they are dropped often in very curious places. I have seen currant bushes and other berry-bearing shrubs on the tops of willow trees and old walls, and I once saw an elder shrub growing out of the buttress of a church. Crows are very fond of walnuts, and if they can get one they will carry it for a con-

siderable distance, and try to break the shell against a stone, which failing to do they have been seen to hide it in the grass, and fly off for another."

"Are there any other ways in which trees and shrubs are planted?"

"Yes, Emily; one of the great agents is the winds."

"I have seen often," said Edwin, "plants on the tops of walls and on trees; and wherever there is root-hold there are almost sure to be plants."

"There is no doubt but the seeds were carried there by the winds. The most common in such situations are grasses, dandelions, thistles, &c. When the seeds were ripe, a breeze of wind swept them into the position in which you saw them, where they remained till the wind covered them with dust, or the rain fell and spattered the mud upon them; they then struck root and grew."

"Don't you remember, papa, pointing out to me, last spring, as we were travelling along the rail-road, the cowslips growing along the sides of the cuttings?"

"I almost forget the circumstance now; perhaps you will relate it to me?"

"If you remember, we saw here and there bunches of cowslips; sometimes there were two or three together, and sometimes they stood in clusters of nine or ten. I asked you how it was they grew in that manner. You said it was very probable that, by means of the winds, a seed had been blown over

the bank, and had taken root. The next year it bore a solitary cowslip, which was suffered to ripen. When the seed was ripe and the seed vessels burst, the winds were waving and blowing the stem about, so that they were jerked out of the seed vessels all around the parent stem. The next year they became plants, as we saw them, and in all probability the same fate awaits the seeds which these will yield this year."

"I remember the circumstance now you speak of it, and am glad you remember what I told you. It is in that way nearly all plants of the smaller kinds distribute their seeds. The seeds of some plants have fine downy balloons, shaped something like wings, attached to them, such as the dandelion, lettuce, &c., so that, as soon as they are set at liberty, the winds take them, and away they fly, till they are stopped by a wall, a wood, or a hedge. The rain descends, they get covered with earth,—the next spring they strike root, grow, and propagate a fresh crop."

"I have often noticed how frequently nettles are found growing in hedges, and by the sides of walls and buildings. How is that accounted for, papa?"

"When the seed of the nettle is ripe, it is blown along by the winds till it comes in contact with a wall or other obstruction, where it falls, and there takes root. This is the reason why hedges are always so full of nettles and other weeds."

"Are there any other agents for the distribution of plants?"

"Yes, water. In some of the large rivers of Spain, at the season of the year, oranges may be seen floating down the streams. Also, all along the shores may be seen orange trees growing in an irregular manner, which shows that they were not planted by man. The oranges have fallen from the trees into the water, by a sudden fall of rain the river has overflowed its banks, the oranges have thus been cast ashore, where they have taken root and grown. In the same manner, cocoa-nuts are often transplanted. The monkeys sometimes carry them considerable distances, and then throw them away. In concluding this conversation, my children, let me again call your attention to what you have learned, and let those facts bring your mind still further to adore the Creator of those wonders which I have attempted to lay before you."

CHAPTER V.

PERSECUTED ANIMALS AND THEIR USES.

Persecuted animals and their uses—The wild rabbit—Its destructive character—The weasel—Its uses—The fox and its uses—The rook and its uses—The mole and its uses—The sparrow and its uses—The wasp and its uses.

"In our last conversation, you mentioned the wild rabbit as of great use in thinning the trees planted by the squirrels."

"Yes, Emily, and if you wish for any further information on the subject, I shall be glad to assist you."

"Are there any other animals that assist to eat the young plants, as they spring up?"

"Yes, the hare, but it does not so much eat young trees as the rabbit; the food of the hare is mostly obtained from the open fields, and not from thick woods and forests."

"I have heard that the rabbits breed very fast. What is there besides man to keep them from becoming too numerous?"

"The wild rabbit, if allowed to breed undisturbed, would, in a few years, become so numerous as to devour every green thing that they could get at. Not many years ago, they were preserved in a large

wood in Hertfordshire, and in five years they became so numerous, that in winter, when there was a scarcity of food, they gnawed the bark off the trees as high as they could reach, killing the wood for acres in extent. They began to spread over the cornfields, and if they had not been destroyed, they would, in another year, have done a vast amount of mischief. The wild rabbit has many enemies, but the most formidable are the weasel and the stoat."

"I should not have supposed that a weasel could destroy a rabbit."

"A weasel has been known to track a hare for nearly eight miles in the snow, and to weary it out at last, and prey upon it. It does not eat the hare, but fixes its claws into its neck, and then sucks its blood, the poor hare running to escape from its pitiless foe till it drops from loss of blood. When it has satisfied its hunger, it leaves the remains of the hare, which are then devoured by the crows and jays. With regard to the rabbit, it will never attack the old ones if it can find young ones. It will, when hungry, enter the burrow of a rabbit, and destroy every one of its young, before it will commence its meal. After satisfying its appetite, it will then retire till hunger compels it to enter another hole, where the same destruction again takes place."

"Now I think I see the use of the weasel, papa."

"What is it?"

"To keep the rabbits from becoming too numerous."

"Yes, and not only the rabbits, but rats and mice, fall a prey to its rapacious appetite. A few years ago, a stack of corn stood in a field which was much infested with rats. All at once it was noticed that the rats left the stack,—not one could be found. In a short time it was found that a weasel had taken up his abode in a hedge close at hand, whose presence had disturbed the rats. Some time since it was found that the Forest of Dean was much infested with mice, so much so, that they became so numerous that they began to eat the roots of the trees, and thus doing a vast amount of mischief. The cause of this mischief was the persons who had charge of the forest had given orders to shoot all the vermin, as they are termed, and thus the whole forest became overrun with mice.

"Has the rabbit any other enemy besides the weasel?"

"Yes, the fox; although he must have his couple a-day, he is not half so rapacious as the weasel, for the fox only kills what he wants to eat. The fox will also eat the weasel when sharp driven by hunger, or in fact almost anything else that comes in its way."

"Then," said Edwin, "the fox is of some use, besides being hunted?"

"Yes; he has his duties to perform, which are to assist in keeping the rabbits, partridges, and pheasants from becoming too numerous."

"I have often thought, papa, that all these little

animals have some duties to perform, if we only knew what they were."

"You are right, Emily; and what appears most strange is, that those animals which are really useful are the most persecuted. Look, for instance, at the fox; if it had not been preserved for the chase, it would, in this country, have been extinct; yet, if it were not for the fox and weasel, rabbits and partridges would become so numerous as to be a pest."

"I often think, papa, that the rook is very much persecuted," said Edwin. "Do you think that it deserves the character for pilfering that it receives?"

"The rook is one of the best friends the farmer has; and the farmer generally thinks him an enemy. The rook is a bird of great appetite, and, when it has its young to provide for, it is incredible the amount of food that they will consume."

"What is their principal food?" said Edwin.

"Their favourite food is the grub of the cockchafer. This grub has been known to destroy whole meadows, as it mostly feeds upon the roots of grass. In a village in Cambridgeshire, the rook was voted by the parishioners as a nuisance, and a penny per head was given for all that were destroyed. In a few years, there appeared a grub which eat off all the young corn and seeds; then arose the question, how were they to get rid of them? They tried to poison them with lime and salt, but it had no effect whatever. One day, by accident, a farmer opened

the gizzard of a rook, and, to his surprise, instead of finding corn or potatoes, as he had anticipated, he found those identical grubs. Thus they found out that the only thing capable of destroying the pest was the rooks. From that time the rook has been looked upon as a friend. And, if in dry weather the grubs and worms are scarce, the farmers do not grudge them a little corn. The rook may often be seen on ground that is newly sown, which often leads the farmer to suppose that he is there to pilfer; but, instead of that, he is there after the grubs that the plough and harrows have turned up. The rook sometimes pulls up the young corn; but that is only when there is a grub or wireworm at the root. Thus you see that the rook has its duties to perform, as well as the other small creatures which we have mentioned."

"Really, papa, I am quite surprised to hear that these little animals are of so much use. I never before thought they were of any use, and that it was the duty of every person to destroy them."

"There is another little animal which I wish to speak of, and that is the mole. There is not an animal in England more persecuted than that is, and there is not an animal of its size of more use."

"I have often heard the farmers and gardeners complain of the mole as doing so much mischief."

"So have I, Edwin; and it is considered one of the farmer's greatest enemies, because it turns up earth while in pursuit of its prey.

"Do you know, papa, what the mole subsists upon?"

"The mole, like the rook, feeds upon earthworms, grubs, larvæ of insects, wireworms, and other insects which feed upon roots. Those burrows which we often see, and which give such an offence to the farmer, are the mole's traps—his hunting grounds. The mole has no permanent home, but changes his place of abode as circumstances demand. He always contrives to fix his temporary abode where there is plenty of food. At first, his burrows are short; and it is into these burrows that the insects stray of which he is so fond. If he finds sufficient insects in his burrows, he does not enlarge them; but, when food becomes scarce, he pushes his burrows further. In this way in time he would, if unmolested, destroy millions of insects that would destroy the crops. The quantity of insects that they destroy is enormous."

"It seems, papa, that the Creator made all things for a wise purpose. I always had an idea that such animals as the mole were only pests, which it was man's duty to exterminate as quickly as possible."

"Before I conclude this conversation, there is another little creature which I wish to call your attention to, and that is the sparrow."

"Really, papa, can you say any good thing about such a noisy, thievish creature as the sparrow?"

"The sparrow is of great use; and but for its services we should in a short time be so infested

with various kinds of insects, that they would devour all that comes in their way. The chief food of the sparrow is insects, and it so happens that when the insects, such as caterpillars, &c., are the most numerous, the sparrows have large broods of young ones to provide for, who, for the most part, from the moment they are hatched till they leave the nest, are incessantly calling out for food. It is during that period that the sparrows destroy millions of young caterpillars in a very short time. The people of one of the islands between France and England, on one occasion, determined to rid themselves of the sparrow, and paid to have the birds destroyed. They succeeded so well, that in a short time they were able to say that there was scarcely a sparrow to be seen. As soon as the sparrows disappeared, a new race of foes appeared—which were myriads of flies—which eat up the young turnips and cabbages; and, in fact, there was scarcely a green thing which escaped their ravages. The good people learned too late that it was the sparrows who had thus kept these insects from becoming too numerous. Thus you see, my children, even the poor little persecuted sparrow has its duties to perform, and without it we should get on but badly. Another great destroyer of insects is the wasp, who seems to kill them not only to satisfy its hunger, but for the love of destruction."

"I never yet, papa," said Edwin, "ever heard before, a person say a good word for the wasp."

"Perhaps not, and yet for all that it has its duties to perform; and, if those duties were not accomplished, we should soon suffer severely. The wasp is supposed to be a great enemy to man, but such is not the case. The Allwise Creator has sent it to be of use, and it is because we do not know enough of its habits that we are apt to condemn it. As I said, they destroy caterpillars by thousands, and not only do caterpillars fall a prey to them, but flies of every description. The butchers in France will not destroy a wasp or hornet, but rather encourage them to their stalls, as they destroy the flesh flies. When an animal dies the flesh flies deposit their young by thousands in its carcass; and it is the wasp, the hornet, and the rook, that devour them. If it were not for the rooks, moles, sparrows, and wasps, the caterpillars and flies would produce a famine."

CHAPTER VI.

PRESERVATION OF ANIMALS.

How the hedgehog, dormouse, and other animals that sleep during the winter are preserved—The curious savings bank—The fat of the animal—How the frog and bat are preserved without apparent nourishment—Why birds come to us in spring and leave us in the autumn—Why water-fowl fly southward in cold weather—The use of the camel's hump—Reflections on the chapter.

"I SHALL in this conversation try to lay before you the wisdom that is manifested by the Great Creator in the preservation of animals. I have shown you in our last how the insect world was held in check, and I have no doubt that you will be equally surprised at the wonderful manner in which animals are preserved."

"I am glad you are going to speak of that; for I have wanted to know how such animals as the dormouse, the hedgehog, bats, and many others subsist through the winter."

"These animals have the power of going to sleep during the cold weather, and thus they escape starvation. If they were as active in winter as in summer, they would require food. Now, the food of most of the animals which you mentioned is insects, which in winter are not to be had."

"Do you think that they require no subsistence during the time which they spend in sleep?"

"Yes; but not to the same extent as if they were in a state of activity."

"I do not see how they can get it; for the hedgehog which we found last winter was as still as if it was dead, and therefore it could not catch its food."

"You are right, Emily; and now I will explain to you how the animal is supported during its four months' sleep. Did you ever notice that when a man who is of a thoughtful disposition earns more money than he wants, he often puts by a small sum weekly into the savings bank?"

"Yes, papa, I have seen that; but I really do not see what that has to do with animals lying torpid."

"Wait a little and you will see. The man saves because he earns more than he wants; but there may come a day when he will spend more than he earns: then he will find his savings useful. It is just the same in the animal world; every animal, as far as I am acquainted, is possessed of a sort of savings bank."

"Really, papa, you make me laugh to hear that animals have a savings bank."

"It is a fact, and you have seen it scores of times."

"I do not remember ever seeing one, and if I did I should not know it, perhaps."

"You are right, Edwin; I do not think you would unless you were told. Have you ever been

into a butcher's shop and seen a whole bullock or a sheep hang up?"

"Yes, papa, I was there this morning."

"Next time you go, if you look into the carcass of the animal, you will see great quantities of fat in the hind part of the carcass."

"I have seen that often enough."

"That fat, Emily, is the animal's savings, and that part of the sheep, about the kidneys, is the bank. Not only does the animal deposit a quantity of fat about its kidneys, but in all parts of its body. Now, this fat can only be deposited there when the animal gets abundance of food. Now, suppose there comes a time when it cannot get sufficient food, what happens to it?"

"It gets less and less every day," said Edwin.

"And what part of the animal disappears, Edwin?"

"The fat."

"You are right, the fat has gone to help to support the animal, and has gradually disappeared. It is very curious, if you look into the back of a very lean animal when dead, you will find a sort of loose bag; this bag held the fat which the animal deposits away. If it were not for this property which animals possess, such animals as are exposed to the inclemency of a severe winter would perish with cold and hunger. Let us suppose a buffalo on the prairies of America. In summer the animal gets very fat; but, as the cold of winter sets in, its food

gradually diminishes till it gets but very little; when this is the case the fat is gradually absorbed into the system, and thus the animal is saved. If it were not for this wonderful provision, a scarcity of food for three weeks would destroy every buffalo in North America."

"Now you understand the uses of the fat in animals?"

"Yes, papa, it is to support the animal during a period of scarcity."

"Yes, Edwin; and now that brings us to how those animals are supported that cannot get anything to eat—as the bat, and many others. You are aware that they roll themselves up, with their noses in the thickest part of their warm fur, as if they knew that they should not want to breathe, fall asleep, from which they do not awaken till hunger calls them. During the time they are asleep they breathe but very little, and consequently want but little nourishment, and what they do want is supplied from the creature's own body. Frogs lie torpid during the winter, and do not breathe in the least. I have seen them taken out of ponds where they were found lying three feet deep in mud, and two feet of water over the mud; therefore it was impossible for the frog to breathe in that situation."

"Are there any other ways in which animals are preserved in time of scarcity?"

"Yes, Emily, there are some birds which live

wholly on insects, as martins and swallows, and several others which come to us in spring."

"I have often wondered why they leave us in the autumn, and return in spring."

"It is one of those wonderful arrangements of the Creator which man has called instinct, which we do not understand, but which in the case of animals and birds serves in the place of reason. We do not know what directs the swallow to come to the western part of Europe to lay its eggs and rear its young, unless it is because of the rainy season, or from a scarcity of insects, which are its natural food. These birds are called migratory, because they move from one part to another. It is very remarkable that these birds come just when the insects begin to appear; but when they have their young to provide for, then the insects begin to appear much more numerous: thus it is, when the creatures' wants are the greatest, the most food is to be found."

"Do you know why they leave our shores?"

"Yes; as soon as the cold weather sets in, the insects disappear, and the birds can get nothing to eat; and instinct tells them that they must go to some other part, where they can find their food in greater abundance."

"I have noticed, papa, that there are some birds that leave us in spring, and return towards the north to lay their eggs and rear their young."

"Yes, there are several, as the fieldfare, the snipe, and the teal, and several others. It is very

curious to notice in the winter, when a sharp frost sets in, with a fall of snow, what a host of strange birds appear about our rivers and ponds. These, for the most part, are water-fowl."

"But why do they come here?"

"Simply because the rivers and lakes where they mostly resort are frozen over, and they cannot find sufficient food to subsist upon. It is then the wild geese and ducks visit us. No sooner does the wind get southward than you may see these northern birds gently winging their way towards the north. If a sudden fall of snow takes place, you may see the larks are in great agitation, and fly screaming about; and in about an hour from sunrise, you may see them on the wing, all flying in a southerly direction. There is one more instance, which I will mention as worth coming under your notice, and that is the camel.

"Yes, papa, I have read about it, and know all about it," said Edwin.

"Then tell me, my son, of what use the hump on its back is?"

"Why, papa, it is put there by Nature."

"True; but Nature did not put it there in vain, no more than gave it a small head and long neck, and a stomach to hold water."

"I am sure I do not know, papa."

"Without that huge hump the creature would no more be able to cross the desert than a cow or horse. That hump is all fat. The camel has two savings

banks—one inside, and one on the outside. It is these humps that partly support the animal, when on its long and toilsome journey. I was told by a gentleman who had travelled in the East, that no Arab will start on a long journey without the hump of the camel being well extended; in fact, they consider them unfit for work if such is not the case.

"These are, my children, a few of the ways in which the Allwise Creator preserves and keeps alive myriads of beings; but for these wonderful means, the whole of the lower animals must perish from the face of the earth. I have only directed your attention to a few instances; there are plenty of others, which, I have no doubt, now your minds have been directed to them, you will easily learn yourselves."

CHAPTER VII.

FIRE.

Introduction to the subject—Ignorance of common objects—The best means of producing a fire—The cause of flame—Why large fires are difficult to extinguish—The oxygen of the air—Why coals will not catch fire so easily as chips—What is a fire?—What wood contains plenty of hydrogen—Patent firewood.

"REALLY, papa, I have thought a great deal about our last conversations; and the more I hear, the more I want to know."

"I am glad to hear you say that; and if there is any thing in particular that you want to understand, I shall be glad to assist you, if I can."

"There are so many things, and I want to know about them all."

"I am happy to hear that; but, in your hurry to know many things, you must not forget to lay a good foundation upon which to build your pyramid of knowledge."

"I, too," said Edwin, "wish to get on as fast as I can; but I do not like to aim at too many things at once, but to take it a little at a time. I always find that it answers best, as I get on slowly, but surely."

"You are right; you may not get over so much

ground, but you do your work much better. Now, Emily, will you tell us one of those things which you wish to understand."

"The subject, papa, is fire."

"Why I do not think that there will be much difficulty in explaining that, as there is not much philosophy in so common a thing as fire."

"I am afraid that you mistake the meaning of the word 'philosophy.'"

"Does it not mean the studies of very wise and learned men?"

"In some sense it does; but the best meaning that I can give you is, the love of wisdom."

"I love to gather knowledge," said Edwin.

"But to apply that knowledge to good and useful purposes is wisdom; the desire and pursuit of wisdom for the love of it is philosophy."

"Thank you, papa; but really I cannot see what there is in a fire for us to have much conversation about."

"That shows, Edwin, how little you are acquainted with the subject; and it is really lamentable how little these things are really understood. You saw that gentleman talking to me this morning?"

"Yes, papa."

"He was telling me that he had been to the expense of a pump, but not a drop of water could they get up; and yet, when the pump was first put down, no pump could work better. There was plenty of water in the well, but not a drop could be

obtained. He had some clever men to examine it, and they all declared that not a better pump could be made; and they all ended in saying, that 'there was something wrong somewhere.' One man said he was sure there was no water in the well, and would examine it, when it was discovered that the top of the well had been made air-tight; thus there was no pressure upon the water to force it up. I mention this anecdote to show you how little the most 'common things' are understood even by some practical men. Now, Emily, we will go on with our subject, if you will tell us how to light the fire."

"O yes! papa; I know all about it; and I can tell you all from the beginning to the end. In the first place, you put straw, shavings, or paper, or any light substance, at the bottom of the grate. I like straw best, particularly wheat straw, as it has more substance in it than the others. When the straw is placed properly,—that is, in a horizontal direction,—we then put in some sticks, chips, or anything that will easily take fire—I like deal chips the best, as they easily take fire; then lay on some moderate-sized pieces of coal, apply a light, and the process is complete."

"Now, Emily, why did you not put the coals at the bottom, the wood in the middle, and the straw on the top?"

"Really, papa, you make me laugh, I should like to see you trying to light a fire in that awkward

manner. Why, you would not get it to burn all day."

"Why not?"

"I do not know why, except that the coals would not ignite, and I think that is a good reason."

"You have gone to work, Emily, in a very skilful manner; but I perceive that you do not understand the reason for it, and it is my province to enlighten you. In the first place, you lay the straw at the bottom of the grate, then the chips and the coals. You put straw at the bottom because it is easily made to flame, the flame from that ignites the chips, and the chips the coal. In the first place you wanted a substance that would readily give out a gas, and that being ignited, would give out a flame."

"Yes, it is hydrogen."

"O yes! I remember now there is a great deal of it in wood. It is one of the principal things that support the tree."

"You are right, and now you will see that when heat is applied to wood it is the first to leave it.

"Now, the moment you apply the candle or match to the straw the heat causes the hydrogen to escape, and as it escapes it catches fire, and once the hydrogen begins to escape from the straw or wood there is great difficulty in stopping it. That is the reason why large fires are so difficult to extinguish. When we have set free the hydrogen, we should not have much of a fire if it was not for the oxygen of

the air, which rushes to the flame, and thus the two together cause the bright white flame. The moment the hydrogen is on fire, the oxygen of the air rushes to support it. Thus you see that the heat which is produced causes more hydrogen to escape, and thus the heat is increased. This is the reason why fires spread so rapidly. A match would not have set your chips on fire, because there was not heat enough produced to set free the hydrogen, but when the flames became stronger the hydrogen from the wood began to escape. It is the same with the coals; they want a still larger amount of heat to set the hydrogen free, more than straw can produce. Thus you see we are obliged to use chips, or pieces of wood, which give out more hydrogen, and conse-consequently produce a stronger flame."

"But," said Edwin, "I do not see why the heat should increase."

"It is one of those laws of nature that is not clearly understood. All we know is that oxygen, hydrogen, and carbon, decomposing together, or separating from each other, produce caloric, or that substance which we usually term heat."

"Then are we to understand," said Edwin, "that a fire, as we term it, is nothing more than certain substances, such as wood, coals, &c., undergoing a chemical change, and that during the process the substance which which we call heat is given out?"

"Exactly so; it is nothing more."

"Now I understand why we use light substances at first when we light a fire," said Emily.

"Why?"

"Because it is easily made to produce heat. I have a question to ask," said Emily.

"What is it?"

"What substances do you consider the best for lighting a fire?"

"A very useful question, and at first does not seem very profound. I should say deal shavings, as they contain a great amount of hydrogen."

"Yes, papa, they blaze away fast enough; but then they leave no substance behind them."

"O! I see; then shavings will not do very well, as they contain plenty of hydrogen, but not carbon enough. What do you say to paper?"

"That has but little substance in it. Not much carbon in paper. Then it is not fit for lighting a fire with, therefore we must look for something else. What do you say to straw?"

"Wheat straw," said Emily, "does very well; as for the others they have but little carbon in them, as you call it, and in a town wheat straw is not always to be obtained. Then, what must we have? Let me think for a moment. Have you ever seen what is called patent firewood? it is pieces of wood dipped into oil, rosin, tar, or some such inflammatory substance. All you have to do is to put two or three pieces into the grate, apply the light, and they are quickly in a blaze."

"Why is that, papa?"

"The composition into which the wood is dipped has in it a great amount of hydrogen; and as soon as it begins to escape, it being so near the wood, which is deal, they are both in a flame at the same moment.

CHAPTER VIII.

FIRE (CONTINUED.)

Why cinders will not produce flame—Why does a fire go out?—Ashes—What is the difference between good and bad coals?—The amount of hydrogen in a ton of coals—Why the fire burns fiercer when broken up—Why will not stone, chalk, &c., do for fuel?—The use of bellows—Why small explosions sometimes occur when the fire is burning.

"In our last conversation upon fire we were conversing upon the best substances for lighting a fire. Which is the best to put on first,—coals or cinders?"

"I suppose you want to know which will part with its hydrogen quickest?" said Mr. May.

"Yes, papa."

"I should prefer those coals which have been partly burned to either coals or cinders."

"Why?"

"Cinders contain no hydrogen, and consequently they will not give out a flame, and therefore are not so liable to ignite as coal; on the other hand, coal is in small solid pieces, which do not give out their hydrogen so readily as those pieces which are half-burned. The reason that half-burned coals give out their hydrogen quickly is, they are more rough and

hollow, and consequently the heat is admitted more readily."

"How is it," said Edwin, "that when all the hydrogen is consumed the fire still keeps alight?"

"During the time the hydrogen is consuming, it is igniting the carbon, which is the slowest, and therefore the last to take fire; now, when all the hydrogen is gone, it leaves the carbon red hot, as it is termed. There is still combustion going on between the carbon and the oxygen. The carbon, or cinders, will not flame, but will burn with a steady heat."

"Why will not cinders flame?"

"Because they have no hydrogen in them."

"I have often noticed the kitchen fire," said Edwin, "and you may divide it into three parts: first, the coals that have been put on last, and have not given out all their hydrogen; second, the carbon or cinders, which are red hot; and third, the ashes at the bottom."

"What happens, papa," said Emily, "when all the hydrogen and carbon is consumed?"

"The chemical action ceases, heat ceases to be evolved, and we say the fire is gone out."

"What are the refuse or ashes, as they are termed?"

"There is no fuel but contains some substance which is termed inorganic matter; from wood there is left a grey substance called ashes; if these ashes were pure, and we were to analyze them, not a

particle of hydrogen or carbon could be found in them, and consequently they have nothing in them to support combustion. In the best of coal inorganic substances may be found; there are none that may be termed pure but are mixed up more or less with substances which will not consume."

"Then, papa, I suppose those are called the best coals which contain the most hydrogen and carbon?"

"Yes, all substances which we get besides these are useless as fuel."

"On that, I suppose, depends the quality of the coal?"

"It does; coals can be bought at sixteen shillings per ton, and I can give as high as twenty-four; but the value is easily perceived when we burn them. Those for which I gave twenty-five shillings per ton contain but a small quantity of ashes, and consequently contain more hydrogen and carbon; but in the cheap coals I shall find a great amount of waste, so that you see the high-priced coals are no dearer in proportion than the low-priced ones."

"Do you know what amount of hydrogen there is in good coals?" said Edwin.

"I cannot tell you accurately, but at the coke ovens it is generally considered that forty-two cwt. of coals will produce twenty-five cwt. of coke, or cinders; thus you see there is twenty-five cwt. of carbon and inorganic matter, and seventeen of hydrogen."

"I have often noticed that when a fire burns slowly, as soon as it is broken up it then begins to flame."

"When there is not a sufficient current of air through it the hydrogen escapes, because there is not oxygen enough passing through the fire to cause it to ignite, and therefore the hydrogen escapes with the smoke. If you wish the fire to flame, you raise it or break it in pieces; you have then given a passage to the oxygen, which then supports the hydrogen, and causes the flame."

"I think, papa, I know now why some substances, such as coal, wood, turf, &c., will burn, while stone, chalk, &c., will not."

"I have often wondered," said Edwin, "why stone and earth will not burn."

"Simply because they contain neither hydrogen nor carbon."

"And I think," said Emily, "that I can tell you what substances are best adapted for fuel."

"I shall be glad to hear your opinion, Emily."

"All substances which contain hydrogen and carbon will burn."

"You are right; all substances which contain these two elements will burn, but at the same time some of them would be very expensive fuel; for instance, no person would think of burning wood (although it would serve well for fuel), on account of its cost. I suppose you mean that all substances which contain carbon and hydrogen will burn."

"Yes, papa, that is what I intended to say."

"Edwin and you have come to right conclusions concerning fuel, but I will just repeat what you have said. All substances which contain hydrogen and carbon will burn, while those which are destitute of them will not."

"I have often, when the fire has been nearly out, taken the bellows and blown it; what was the cause of it so soon beginning to burn fiercely?"

"When you used the bellows, you caused a greater quantity of oxygen to go into it than would have gone if you had not blown it, and consequently it caused the fire to burn more briskly.

"Should you blow a fire at the top or bottom," said Emily.

"It is best to blow as near the bottom as you can, so that all the oxygen gets consumed before it escapes from the fire."

"Sometimes, when I have been sitting by the fire, I have heard a loud cracking in it, and seen pieces of coal fly out of the grate. What is the cause of that?"

"It may be caused in two ways; first, by a stone getting into the fire; and secondly, by some of the hydrogen getting confined and mixed with the common air; as soon as the fire gets at it, it explodes. I will show you what I mean. I fill this bladder half-full of air; now force into it some common gas, such as we burn in the streets. I make a hole with my knife, so that the gas can escape, apply a

flame, and you see it is gone off as loud as a pistol."

"That is a reason," said Edwin, "that the coal should snap and crack, but I do not see why the stone should, as there is no hydrogen in that."

"True; but that cracked from another cause, which was this: as soon as the heat began to enter the stone, it caused the stone to expand, and as the stone would not readily yield, it burst into two or three pieces, and the noise that you heard was the bursting of the stone.

CHAPTER IX.

SMOKE.

What is smoke?—Why the wick of a candle ceases to smoke when it is lighted—The reason that smoke ascends the chimney—Why chimneys smoke—How to cure a smoky chimney—Why two fires will not burn well in the same room—How to extinguish a fire in the chimney—The causes of chimneys taking fire—Why do they require tall chimneys in large factories?

"We have discussed the subject of fire in our last conversation; now, papa, will you tell us a little about smoke?"

"I shall feel happy to answer any questions, or to explain any subject relating to it, that may have come under your observation."

"Well papa, I have been trying for some time to ascertain what smoke is. Will you be kind enough to tell me."

"With pleasure. Smoke is unburnt carbon, that is being continually given out when a fire is burning. If you notice a fire that is smoking very much, if you can get the fire to flame, the greater part of the smoke or carbon is burned. If you blow out a well-lighted candle, it causes a smoke, but the moment the candle is lighted, the smoke ceases, because it is being consumed."

"Then, all the smoke that we see issuing from chimneys is so much waste."

"It is; many persons have tried to introduce smoke-consuming apparatus into furnaces, but as yet none of them answer the purpose very well."

"Do you know why smoke goes up the chimney, papa? The reason why I ask the question is, when we were coming across the fields, we saw some men burning grass, and that smoke did not go upwards, but along the ground."

"The reason that smoke goes up the chimney is, smoke is lighter than the air, the heat of the fire causes the air near it and above it to expand, which makes it lighter than the air in the room, consequently it rushes up the chimney, taking the carbon or smoke, as we term it, up with it; when the oxygen is burned out of the air, the nitrogen, which is left, is lighter than the common air; and also, being heated, the weight of the cold air causes it to rush up the chimney, blowing the smoke up at the same time. Thus you see the column of air in the chimney is lighter than the air outside; therefore, the rarified air is continually being forced upwards."

"Sometimes the smoke refuses to go up the chimney, how is that accounted for?"

"The reasons for that are various. You remember our parlour chimney smoking?"

"Yes, papa, and that it always ceased when we opened the window which was opposite, but I never knew the reason."

"The reason was this, when all the doors and windows were shut, the fire could not get sufficient air to support it from the room; therefore it rushed down the chimney, and the smoke was forced into the room."

"I have known our kitchen chimney smoke when all the doors have been open."

"Yes; and do you know the reason?"

"No, papa."

"You know that there are several flues leading into the chimney; sometimes, when the doors of the flues are left open, streams of cold air rush into the chimney, and thus the stream of rarified air is cooled before it reaches the top, this was the cause of our chimney smoking, and I have no doubt hundreds of others. There is another reason why chimneys smoke, and that is when they are very broad at the bottom, and narrow at the top. When this is the case, the fire draws into the mouth of the chimney a large volume of cold air, which condenses the rarified air before it reaches the top of the chimney. There is another source of smokey chimneys, and that is when the fire is a considerable distance from the throat of the chimney, this fire never burns, and to use a common expression, the chimney 'never draws well.' The reason is, instead of the air being drawn through the fire, it draws the air above the fire, and thus a large quantity of cold air is continually in the chimney. Old chimneys that have loose bricks in them, through which the air can find its way, will

also cause a chimney to smoke, by currents of cold air getting into the chimney, and thus rendering the air too heavy to ascend."

"Which way do you consider is the best to cure a smoky chimney?"

"It all depends upon what is the matter with it. Before we can cure, we must know the cause of the disease."

"Suppose it was like our parlour chimney, which would not draw, unless the window was open?"

The best cure for that was a tube communicating with the air, beneath the grate. It serves a threefold purpose; first, it would prevent the room from smoking; secondly, it would prevent a draught; thirdly, it would not consume the air in the room, thus the room could be warmed with less fire."

"Supposing, papa, that the fire-place was too far from the neck of the chimney, how would you manage that?"

"Shorten the neck of the chimney to the fire, by means of a piece of sheet iron."

"What effect would that have upon the smoke?"

"First, it would prevent the warm air from getting cold before it got into the chimney; secondly, it would cause more air to rush through the fire, causing it to burn brisker, and producing a sharper draught in the chimney."

"I have often observed in winter, when there is a

fire at both ends of the school-room, one of them never burns so well as the other."

"I suppose they are two open grates?"

"Yes, papa."

"The reason of that is, one extinguishes the other. The one that burns the best draws the air from the other, so that it cannot get a sufficient supply."

"I have also noticed when one fire is burning very fiercely, the other chimney smokes. As soon as this happens, the teacher opens a window near, and then it ceases smoking directly. How do you account for that?"

"Simply because a supply of air is drawn through the open window, instead of down the other chimney."

"If a chimney was to get on fire, papa, what is the best method of extinguishing it?"

"As soon as possible close all the doors, and thrust into the throat of the chimney a bundle of wet straw, a wet blanket, or anything that would not readily take fire."

"Why would you do that, papa?"

"So that the fire should get no air from beneath; therefore, instead of the air rushing up the chimney, it would draw the air down, and thus prevent the burning soot from flying out at the top. Thus you see that all danger is stopped outside. To extinguish the fire, if it is possible, get a ladder, and lay some wet sacks, blankets, or anything that would

hinder the air from getting to the fire. Let them remain for five or six hours, and, by that time, the soot will be extinguished."

"What is the cause of chimneys taking fire?" said Edwin.

"When the chimney is full of soot, and a hot blazing fire is sending up sparks and flame, the soot is liable to take fire. Houses often get on fire through fire in the chimneys, and much mischief is often the result."

"I have read," said Edwin, "that there are chimneys in the manufacturing districts from fifty to sixty yards in height. Why are they such a height?"

"Yes, there are chimneys quite as high as that, and six feet square at the base."

"Why do they want them so large?"

"Because they want to get as great a draught through the fire as they possibly can; for the greater the draught, the more heat is evolved from the fire. The draught of such chimneys is very great, as you may perceive by the rapidity with which the smoke rushes from the top. Another reason for their being so high is, the law compels their owners to build them above a certain height, to carry into the atmosphere the dense columns of smoke which issue from them, which would otherwise contaminate the air."

"What becomes of all the soot that goes into the air?"

"If the chimneys were not of a considerable height, the soot which issues from them would fall near the chimney; but, on account of their being so high, the soot is driven to a greater distance; sometimes it may be perceived for ten miles."

CHAPTER X.

THE WONDERFUL GIANT.

"I SHALL commence our conversation this evening with a story."

"A story, papa!" said Emily. "I thought stories had nothing to do with philosophy?"

"Perhaps they have not, in a general way; but story that I shall relate is connected with philosophy; and so, once upon a time ——"

"Why, papa, that is how all the fairy tales begin; surely fairly tales and philosophy have no connection!"

"Now, Emily, listen. Once upon a time there was a mighty giant upon the earth; he was so large that he could cover nearly the whole earth, and so strong that no power could be found to bind him. It is said of him that, on one occasion, he by some means got confined in the earth, which caused him to struggle so violently, that he actually kicked a large piece out of the earth, and sent it as high as the moon.

"Really, papa, this is a most extraordinary story."

"It is, Edwin; but let me go on, if you please. If all is true which is said about him, kicking a piece of the earth up to the moon is merely child's

play. Now, if you let him alone he is as harmless as a baby, but if you try to confine him it is then he shows his wondrous powers. If you confine him too much he is sure to burst away. I do not believe there is a power upon earth that can confine him, and yet so childlike is he that he will work at any one's bidding. He will not work unless he is fairly paid; and if he does not receive his own price away he goes, whether he has finished his work or not.

"Many have been the attempts to confine him for the purpose of making him work, which has at length been accomplished; and this no doubt would have been done long ago, only the persons who undertook the task did not know how to make his harness, nor properly understand the best way to give him his food."

"Does he drink as well as eat?" said Edwin.

"Yes, he wants a great amount of water; but he must have it scalding hot: cold water would poison him. They found out at last that three things were necessary to make him work. First, he must have as much food as he chooses, and he requires nothing more."

"That is cheap enough," said Emily, "if he does not eat too much; but perhaps he eats a bullock at once?"

"Secondly, he must have proper harness, for on this depends in a great measure the amount of work he will do; for if the harness does not exactly suit

him he will tear it to pieces in a very short time, throwing the pieces in all directions, and doing a great amount of mischief. Thirdly, he must have some one to guide him, as he has no eyes, arms, legs, or head."

"Now, really, papa, what a curious story it is; why, we know it is not true. It beats all the giants that I have ever heard or read of."

"Stop, Edwin, and listen, and perhaps you will alter your mind. Some persons say that the giant has a large cave in the middle of the earth,—others say that he came originally from the sun, which last I think is the truth. We might ask him, but as he has no head he is both deaf and dumb."

"If it is true, papa, does he ever do any mischief?"

"Sometimes he does; and, on one occasion, he got confined in the earth, which irritated him so much, that he made such a dust, that a whole city, with all its inhabitants, were buried in it. Yet, for all these little matters, the giant is not a bad one, for, if it were not for him, we should not live a single hour; if it were not for him, we should have no fruits, flowers, or any vegetable life. But for him, there would be no winds, rain, or dew; no clouds, snow, or hail; no ocean of water, no running streams; there would be no animals, or any living creatures whatever; the earth would be a perfect blank—a useless mass of matter."

"I never heard before that a giant caused all these things; and I am sure I never saw him."

"No Edwin, and you never will, as he is invisible to mortal eyes; but listen, and you shall hear a little more about him.

"There is a race of people living upon an island, about three thousand miles from the eastern shores of America, who have, by means of proper harness, and a great deal of coaxing, got him to do all sorts of work. They will tell you he is one of the best servants in existence. If he is well fed, and properly attended, and has well-fitting harness, he will work night and day for years, as he never tires —he does not know what it means. No fire can burn him, no weight crush him, nor no labour weary him. He will do almost any kind of work. Sometimes you may see him boiling a potato, pumping a mine, wielding a mighty hammer; and sometimes he may be seen running across the country, with three or four hundred people, faster than any race-horse.

"If you go to the ocean, you may see him driving vessels against wind and tide, from ten to fifteen miles an hour. In fact, not a ship or boat could move without his help."

"I know," said Emily, "what it is!"

"Well, what is his name?"

"The wind?"

"No; his name is not wind; but if it were not for him there would be no wind, and I said he would go against wind and tide."

"If you please, papa, it is steam," said Emily.

"No, his name is not steam; but if it were not for him, there would be no steam."

"Is it water, papa?" said Edwin.

"No, Edwin, his name is not water; but if it were not for him there would be no water."

"Is it anything that belongs to the animal kingdom?"

"No; but if it were not for the giant there would be no animal kingdom."

"Does it belong to the vegetable kingdom?"

"No; but it is he that helps to support the vegetable kingdom."

"Then, it must belong to the mineral kingdom?" said Edwin.

"No; but if it was not for the giant the mineral kingdom would be useless."

"I cannot imagine what it can be, papa; is it very common?"

"Yes; it is one of the commonest things we have, and without it we could not have the commonest necessaries of life."

"I am sure we shall never guess it, papa; do tell us, if you please. Is it not strange that we should be surrounded by blessings to such an extent that we are not conscious of their very existence?"

"Do tell us, papa, what it is!" said Edwin.

"Well, children, it is heat!"

"Heat, papa!" said both Edwin and Emily, in astonishment. "Can heat do all this?"

"Yes, and a great deal more than you and I can

think of. It is heat that first upheaved the mountains, and caused the ocean to become dry land; and it is heat that caused all the great changes upon the earth's surface. It is heat that causes life to the animal world. It is heat that causes the vegetables to spring up and flourish; deprive them of it, and they wither. It is heat that makes the minerals of value; if it were not for heat they would be of no use, except as stones. It is heat that keeps the waters of the globe in a fluid state; if it were deprived of its heat, it would be turned into ice, and the ocean, instead of being what it is, would be a solid mass, as hard as a rock.

"I must now close my story about the giant; but before I do so, let us look at the subject a little, and we cannot fail to see one of the great wonders of the Creator. Heat at first seems a small thing; but yet so vast is it, that, if the earth was deprived of it for one single second, every animal and plant would cease to exist. Well might the inspired Psalmist exclaim, 'How wonderful are thy ways, O Lord of Hosts!' When we kneel to our Creator, and thank him for the many blessings which we enjoy, how little do we know the extent of these blessings."

CHAPTER XI.

HEAT.

What is meant by heat?—The different methods of producing heat—Electricity—Percussion—Curious method formerly resorted to by smiths to obtain a fire—Latent heat—What is latent heat?—Heat produced by friction—Why oil prevents iron axles from getting hot—Rubbing wood together to produce fire—Heat produced by chemical means—The properties of heat—Heat has the power of transferring itself—It occupies space—It has weight and colour.

"Last evening our conversation was upon the wonders of heat. We will resume the subject, and I have no doubt that we shall find it one well worthy of our examination."

"What is meant by the term heat?" said Emily.

"By heat is meant that sensation which we feel when caloric (that is its philosophical name) is passing from some object to us. I hold my hand on a plate of warm iron; I feel a sensation, which is caused by the heat passing from the plate into my hand. That which causes the sensation is called heat."

"How many methods are there of producing heat, or caloric?" said Edwin.

"Four, besides the great normal source, the

sun—namely, electricity, percussion, friction, and chemical methods."

"How is heat produced by electricity?"

"There is no doubt but it is caused by the rapid friction of the two currents when they meet each other, or it may be caused by their uniting in a chemical manner. Lightning is produced by electricity."

"What is meant by percussion, papa?"

"Percussion means hammering. You have seen a gun cap; fire is produced from it by percussion."

"Is that the reason why they are called percussion caps?"

"Yes."

"That reminds me of what took place a few days ago," said Edwin, "which surprised me not a little."

"Perhaps you will tell us what it was?"

"I went into the smith's shop a few days ago, and his fire was out."

"I suppose there was nothing very remarkable in that?"

"No; but there was in the method in which he lighted it."

"How did he proceed?"

"He made a hole in the ashes, and put in it a few chips, and then proceeded to light it with a match, but the matches would not light; he then very deliberately took a piece of iron, and began to hammer it smartly, and in about a quarter of a

minute the iron was red hot; he then took one of the matches, lighted it, and set the chips on fire. Now, papa, the question is, Where did the heat come from?"

"The question rests upon another part of our subject,—latent heat. You must remember that all substances contain natural heat, and that heat is called latent heat."

"Can you tell us the cause of latent heat?"

"There has been, and is now, a great many opinions upon the subject, but I think the simplest is this. Let us suppose that there was no heat: of course everything would be of the same temperature, or the same degree of cold. Then, if heat was at once created, everything would absorb it,—some things more than others. If I take a piece of iron in one hand, and a piece of wood in the other, we at once feel the iron the coldest; therefore iron takes in less heat than wood. There is a great deal of difference, even, in the temperature of wood. Ash is much colder in the hands than either sallow or maple. Everything contains heat,—even ice and snow. We must now return to your question, 'Where did the heat come from?' Iron, like all other substances, contains latent heat, or natural heat; and when the smith was beating the iron he was driving the particles closer together, and as the iron took up less space the latent heat became more perceptible. You can try the experiment yourself, by taking a piece of iron and striking it smartly a

few times, when you can feel the heat."

"You said, papa, that heat was produced by friction; will you explain it?"

"If you take a button and rub it sharply on a stone, you will soon perceive that it grows hot."

"Yes, papa; I have tried it many times, and have got it nearly hot enough to burn my hand."

"You have often seen the inside of a mill, and noticed how carefully all the axles and cogs of the wheels are oiled. If this was neglected, in a short time, if they moved rapidly, they would become so hot that the woodwork would take fire. It used to be no uncommon circumstance, a few years ago, before iron axles were common, for the wooden ones to take fire."

"Is that the reason why they are so particular about the railway carriage wheels?"

"Yes; if you notice the next time you ride in a railway carriage, you will see a man run round with grease at all the principal stations, to see that they have a proper supply. If this were neglected, the rapidity with which they travel would soon heat the ironwork, which would communicate to the wood, and fire would soon be the result."

"How is it that oils and grease prevent iron axles from heating?"

"You are aware that the surfaces of all substances are more or less uneven; when there is no oil upon these surfaces, when they work one upon another, the uneven parts beat against each other,

and produce heat, something in the same manner as the smith,—namely, by beating. The oil or grease fills up all the uneven places, and, instead of allowing them to strike against each other, it lifts them over."

"You have read in the story of Robinson Crusoe, that the savage Friday produced fire by rubbing two pieces of dry wood together."

"Yes, papa; and, after reading it, Emily and I tried it for half an hour."

"And did you succeed?"

"No; but we made the wood slightly warm. How was it that we could not get a fire as well as the savage?"

"Perhaps you did not rub them so briskly as the savage did."

"I rubbed them till the perspiration ran down my face, and my arms ached."

"Some philosophers think that obtaining fire by rubbing two pieces of wood together with the hands is an exaggeration; on the other hand, travellers assert that it is a fact. The only way in which it can be accounted for is,—in those countries where fire is produced in that manner, the wood must contain more phosphorus than the wood in this country; if such is the fact, there would be but little difficulty in the matter."

"Lighting a lucifer match is another instance of heat by friction."

"You said that heat was produced by chemical means."

"Yes; such as combustion,—as the burning of a candle, lamp, or fire. If I were to pour a few drops of sulphuric acid into a glass of water it would raise the temperature. A piece of phosphorus put into a jar of oxygen would produce heat. If a quantity of vegetables are piled into a heap, decomposition takes place, which produces heat."

"I think, papa," said Edwin, "we shall now remember the different methods by which artificial heat is produced. Will you be kind enough to tell us the properties of heat?"

"The chief properties of heat are four. First, it has the power of transferring itself from one portion of matter to another; second, it occupies a space; third, it has weight; and fourth, it has colour."

"How is it shown, papa, that it has the power of transferring itself?"

"This may be shown in three different ways: by conduction, radiation, and convection."

"Will you be kind enough to explain those terms, or I shall be no wiser than at first?"

"Conduction means being led. If I were to put one end of a bar of iron into the fire, the heat would gradually extend along the whole bar. If I place a ball of red hot iron upon a piece of sheet iron, the ball will give out its heat to the sheet iron, because it is colder. Heat always tries to find its own level, or to make all objects with which it comes in contact of the same temperature."

"How is that process carried on?"

"All metals are good conductors of heat, because the particles of matter of which they are composed lie closely together, and consequently the heat is easily communicated from one particle to another. I will now explain the meaning of the term convection. The meaning of the word, as used here, is conveying or carrying heat from one object to another; a good illustration of it is the tea kettle. Suppose I take a small flask of water, and place a lamp at the bottom,—the water at the bottom is heated first, and carries the heat up into the flask. Radiation is a very important mode in which heat communicates itself. You have seen the stove and pipes in the school?"

"Yes, papa."

"That is a very good illustration of radiation."

"The hot water pipes in the church are another," said Emily.

"The fire in the grate is another," said Edwin.

"Yes; all those ways in which fire gives out heat in all directions is radiation. By radiation the air carries away the heat till it has reduced a heated body to its natural temperature. But it so happens that if I take a ball of hot iron, and suspend it in the exhausted receiver of an air pump, it cools as rapidly, or more so, than if it was in the air; in this case, it cannot be the air that carries it away. The only way in which it can be accounted for is this: iron will receive a certain quantity of heat naturally,

and the moment more is forced into it, it strives to get rid of it. Suppose I take this bottle,—it is full of air, but still, if I chose, I could force as much more into it, but as soon as the force is removed the air will immediately return to its natural level. And may it not be the same with the ball of hot iron? As soon as it is suspended in the air pump, the force is taken off, and the heat therefore passes out."

"I think, papa, you said that heat occupies a space; how is that shown?"

"The ways in which that may be proved are various. If I take a rod of iron, and put it through a hole which was just large enough to admit it when cold, and then heat it red hot, I should not be able to pull it back until it had cooled. You have seen blacksmiths when they have been making bolts and nails; they hammer the red hot iron through a hole to give it a head, and all they have to do to get it out is to turn the mould over, and then it falls out: by cooling it has also contracted. If a rod of iron is measured, and heated in the middle and then measured again, it will have increased in length. Now, the question is, What makes these things become larger when they are hot? Heat, you say; then heat must occupy a space."

"I always understood, papa, that heat rendered everything lighter. If so, how can it have weight?"

"I am not going to assert, my son, that we can take it and weigh it as we would a piece of wood;

but I think I can make you understand me if you give me your attention. Everything by which we are surrounded has what is called a specific gravity, that is, a certain weight of its own. The specific gravity of the air we breathe is fourteen, comparing hydrogen as one. Now, although hydrogen has weight, yet it is fourteen times lighter than the air we breathe. Take a paper balloon and fill it with air; now apply a flame to it, and we shall soon see the balloon begin to expand, and finally mount into the air."

"Now, what made it ascend? It was not the cold air, but the heat that was in the air. This shows us that heat, like hydrogen, is specifically lighter than air; now, why may we not conclude that as hydrogen has weight, so also has heat, which manifests the same property."

"This does not exactly amount to a proof, does it, papa?"

No, my son; but with a little skill, and a proper apparatus, the specific gravity might easily be tested. We now come to the last of its properties, which is colour."

"I did not know that heat had a colour, papa, as we cannot see it."

"Its colour is a sort of pink; a light pink would perhaps express it as well as anything."

"How is it known that it has this colour? I am certain that I see no colour such as you mention."

"You see this rod of iron which I hold in my hand?"

"Yes."

"What colour is it?"

"It is polished iron, therefore a light grey."

"Now I will force a quantity of heat into it, by putting it into the fire. Now it has been in the fire a few minutes, what colour is it?"

"It is a light pink."

"What change has the iron undergone?"

"It has become charged with heat."

"Then it cannot be the iron that has caused this change, but the heat."

"It does appear so, papa."

"Yes; we have introduced a new substance into the iron, and, as might reasonably be expected, we have got a new colour. If I take this glass of clear water, and introduce a new substance into it, as milk, ink, or any substance which will mix, I shall lose the transparency, and get a new colour. That is just what happened to the iron; therefore we may conclude that heat is nearly white."

"How is it that we do not perceive the colour in other objects, as you say that all objects contain heat?"

"Your question is a very natural one. Suppose I take this large glass globe, which holds nearly a gallon. I nearly fill it with water, and now pour into it a few drops of colouring matter. Can you perceive the colour?"

"No, papa."

"Now I have stirred the water, it looks as clear as it did at first; yet you know that the colour is there. Tell me why you do not see that the colour of the water is changed?"

"Because you did not put colour enough in it."

"It is the same with heat; we cannot see it, because there is not enough of it; we cannot discern its colour till a quantity is collected together. The colour of heat cannot be perceived in any object till it arrives at 1000 degrees of heat."

CHAPTER XII.

NATURAL HEAT.

Why some things are colder than others—The value of latent or natural heat—Good and bad conductors—Why some substances conduct heat better than others—Why we have brass handles to ovens and other things when there is much heat—Why we have woollen hearth-rugs—Why we use woollen carpets—How we know that wood is a better conductor of heat than a woollen carpet—Why we paper rooms—Why we use curtains to our windows—Clay floors formerly used, and the result—Brick, stone, and plaster floors—The best floors—Beds—Rushes—Flags—Straw mats—Mattress—Feather beds and wool mattresses.

"In our last conversation, we mentioned the subject of latent heat; I intend to tell you a little more about it this evening."

"What is meant by latent heat, papa?"

"Every substance with which we are acquainted contains heat,—natural heat would have been a better term for it. I dare say you have often noticed the difference in the touch of different things?"

"Yes, papa," said Edwin, "I have. When I am digging in the garden, if I get hold of the iron on the handle of the spade, it feels colder than the wood."

"Then, we should say, iron is a better conductor

of heat than wood. It is latent heat that helps to make everything on earth so beautiful and fair. Not a flower could bloom, a shower fall, or a blade of grass could show its fragile form, but for latent or natural heat. But for this, the ocean, rivers, and lakes would be masses of ice, hard and stubborn as iron, and, instead of their waters teeming with millions of happy creatures, they would be rough and lifeless rocks of ice; the whole globe would be unfit for either animal or vegetable life; the whole round of animated nature would never have existed; and the world, which is now the abode of millions of happy creatures, would have been the habitation of eternal frost and ice. How can the most indifferent mind look upon these glorious works, and not be struck with the wisdom of that Being who planned and put these wondrous laws into operation? The theme, my children, is an endless one; and I wish to impress upon your mind the vast wisdom displayed, and the beauty of these majestic works.

"You told us, papa, that some substances attracted heat more readily than others. Can you tell us the reason of it?"

"Those that attract heat the most readily are hard substances, such as metals, &c.; these are called good conductors. Those substances which are soft, or whose particles are loose, are bad conductors."

"How is it that hard substances conduct heat more readily than soft?"

"I have told you that all substances are composed of minute particles; in hard substances, these particles lie close together, so that the heat readily passes from one to the other. In substances which are soft the particles are not so closely packed together, therefore the heat has more difficulty in passing along it."

"You said, papa, that metals are good conductors of heat—is there any difference between them?"

"Yes; lead is rather a slow conductor of heat: its particles are very loose, as may be shown by the little heat it requires to thrust them asunder, or to melt them. Brass is not so good a conductor as iron."

"How is that shown?"

"You can prove it yourself, by stepping into the kitchen."

"In what way, papa?"

"I think I can tell you, papa."

"Well, Emily, how will you prove by a walk into the kitchen that iron is a better conductor of heat than brass?"

"By the oven handle and the boiler tap. I have often noticed, when the oven has been so hot that you could not touch it with your hand, the brass handle might be taken and held in the hand without inconvenience. Another thing has just come into my mind, and that is, most persons prefer a brass ladle for the dripping pan. I have often noticed

that, when the dripping pan has been hot enough to burn the hand, the handle of the ladle might be handled without injury to the hand."

"I suppose that is the reason," said Edwin, "that brass handles are usually put where there is a great amount of heat?"

"It is; and it is a very useful contrivance. If you were to go into the kitchen, and place your hand on the oven, I have no doubt but you would burn it; consequently, if the handle was made of iron, every time you opened it you would have to take a piece of cloth to prevent your hand from being burned."

"I remember, papa, when I was standing before the fire one day, my brooch got so hot that I could scarcely touch it, while my stuff dress was scarcely warm. I suppose the reason of that was, because the brooch was a better conductor of the heat than the stuff of which my dress was made?"

"Exactly so."

"That reminds me," said Edwin, "of once burning my hand."

"How did that happen, my son?"

"One day last winter, the cook had just put a piece of wood in the fire to make it burn up quickly; when it was nearly all burnt away, she put it on the top of the fire with her hand. This feat incited me to take hold of the poker nearly close to the bars, and the result was I burned my hand with the

poker. I never could understand why I should burn my hand with the poker, and not with the wood."

"I can explain that," said Emily.

"Why was it so?"

"Because the poker, which was of iron, was a better conductor of heat than the wood."

"You said, papa, when we were speaking of oven handles, if handles had been of iron, we should have to take hold of them with a piece of cloth. Why should we have taken cloth?"

"I do not know why we should take cloth, unless it was the easiest to procure; leather would do equally as well. The reason of that is neither of them are good conductors of heat, and, consequently, the heat would not pass through the cloth to the hand."

"Will you be kind enough to name some of the bad conductors?"

"Water, woollen cloth, clay, paper, boards, &c."

"Why do we always have woollen hearth-rugs?"

"Because they are bad conductors of heat, and, therefore, they are not so liable to take fire, if a burning coal should fall upon them."

"You are right, so far; but there is another reason, and that is, when our feet are placed upon them, they do not absorb the heat from them so fast as if we stood upon bricks, or even boards. Thus you see that woollen hearth-rugs are both safe and comfortable to the feet."

"I have often noticed," said Edwin, "that almost every house, even among cottagers, shows some pretension to a carpet. I never can understand what real use a carpet is, except to make the room look neat and comfortable?"

"The carpet is to prevent the floor from absorbing the heat in the room, and at the same time it prevents the boards from attracting the heat from our feet when we stand upon them."

"How do you know, papa, that boards conduct heat better than a woollen carpet?"

"I have no doubt, when you have got out of bed, and put your feet upon the carpet and then on the boards, you perceived that the boards felt colder than the carpet; and the reason is the boards absorb the heat more rapidly than the carpet. Even our ancestors were aware of this fact; and to remedy it they strewed their floors with flags, rushes, and straw; and, when these were not attainable, they strewed them with leaves and small branches of trees."

"I suppose that those were not very comfortable carpets?"

"Perhaps not; but these served their purpose, perhaps, much better than our modern ones would have done; for when the straw, &c., was swept out a great deal of filth was also taken away with it."

"Papa," said Emily, "can you tell me why they paper rooms, as almost all rooms are now papered.

I asked the paperhanger when he was here, and he said it was the fashion. Is that the only reason?"

"No; if you think for a moment, you will perceive that it has a far greater use."

"I do not know," said Emily, "unless it is to make the room look pretty."

"Perhaps that is one reason, but it is not the principal one."

"It makes the house look more comfortable when the rooms are papered," said Edwin."

"Yes; and they are more comfortable, and I will tell you the reason. Paper is a slow conductor of heat, and consequently it prevents the walls from absorbing the heat out of the room."

"Now we come to the window curtains, which are of damask."

"These are also slow conductors of heat, and prevent the glass in the windows from attracting the heat, as glass is a good conductor of heat."

"You were saying, papa, that boarded floors absorbed the heat from our feet; which kind of flooring do you consider the best, as regards comfort and health?"

"I am glad you have asked that question, as it is one upon which I wish to say a few words. Not many years ago, cottagers' houses were usually floored with clay, much in the same style as farmers' piggeries of the present day; and even that was an advance in civilization, as before that they had

nothing but the bare earth. I never remember seeing more than two of these clay floors, and when the cottages were clean they had a very pleasant appearance."

"How very uncomfortable they must have been, and how difficult to keep clean."

"I have no doubt they were often very dirty; but that was not the worst, as they were a very fruitful source of ague, rheumatics, fevers, and other diseases."

"Why do clay floors cause disease?"

"Because the clay floors, being always cold, they were therefore always absorbing the heat from the feet of those who stood upon them. I remember a school with a clay floor, in which there were at least one hundred and fifty children, and in the winter I have seen as many as a dozen huddled round the stove with the ague, and not less than two-thirds of the whole school afflicted with chilblains.

"The next step towards the improvement of the floors of cottages was to pave them with bricks or stones. In the eastern counties of England, you will find every house bricked; in Yorkshire they are paved with stone. In the midland counties, many of the rooms are floored with plaster of Paris."

"Which do you think are preferable?"

"Stone, as bricks are always more or less porous, and consequently absorb the moisture from the earth beneath. Thus you perceive that they are always cold, and, therefore, when any person stands upon them

for any length of time, they absorb the heat from the feet, and the result is chilblains, if nothing worse."

"Is that the reason why the Committee of Council on Education will not sanction payments to be made to schools which have brick floors?"

"Yes, and a very wise regulation it is; and I have not the slightest doubt but it will prevent a great amount of mortality among children, and also prevent the seeds of consumption being sown at school. You asked me which I considered the best and healthiest floors. I should say wood, as it attracts the least heat from the feet."

"Now we are discussing the subject of heat," said Emily, "I have often heard the subject of beds discussed, as to which were the healthiest?"

"There are many opinions upon that subject. Our Saxon ancestors were content to lie on the table, under it, or even on the floor; but, to our ideas of comfort, this must have been very rough indeed."

"What was the next step in the art of bed-making?" said Edwin.

"To collect a bundle of rushes, flags, leaves, or straw, to sleep upon. The next step was to weave the straw into large coarse mats, about eighteen inches in width, from eight to ten feet in length; part of this was rolled up to form a sort of pillow for the head to rest upon. Some of the mats were made of flags. It was upon such beds as these that the nobles reposed. The next step was to

make a large straw mat, and lay it upon a frame raised from the floor. The frames were of massive oak, some of which remain to this day. This mat was called, to distinguish it from the long narrow mat, a mattress. Thus arose the first rude bed. The common people did not incline to so much luxury as a mat or mattress, but were content with a bundle of straw, which, in time, was put into a large bag."

"Do you suppose that lying on straw was as warm as lying on the floor?"

"Yes; because straw does not conduct the heat from the body so rapidly as wood. Straw beds lasted many years. Even at the present day, straw beds are used in the midland counties by the poorer class of peasantry."

"Poor creatures! how miserable they must be," said Emily, very pitifully."

"You need not pity them, Emily, as they have never known the luxuries of any other, and consequently desire nothing better. You must bear in mind that they sleep on beds such as many of the kings and queens of England have slept upon before them. Henry VIII. slept on a straw bed; so you see that these people, after all, enjoy what monarchs a few centuries ago thought luxuries."

"What objection have people now to sleep upon straw beds?"

"I should suppose," said Emily, "because they are hard and cold?"

"You are quite right, Emily; but what makes them cold?"

"I suppose the straw attracts the heat from the body."

"Not exactly; straw is a bad conductor of heat. The reason why straw beds are cold is, the straw allows the heat to escape. It is not compact enough to retain the heat, as the body gives it out?"

"What is meant by cold?"

"It is simply the feeling which we experience when the heat is going out of our bodies too rapidly. I lay my hand upon the table, and feel a sensation of cold; the cause of it is simply the sensation which I feel when there is too great a loss of heat, which is passing from my hand to the table. You feel warm when the heat is passing into the hand, and the sensation of cold is when the heat is passing out of it."

"You think, papa, that straw beds, like clay and brick floors, ought to be among the things of other days, and something else substituted in their places?"

"Yes; and in so doing we want something which is both soft and warm; by warm, I mean something which will not allow the heat readily to escape."

"Feathers, then, I should think, will suit us," said Emily.

"Feathers are very soft and warm, but there is

an objection to them as being too much so. Wool, I think, although it is not so soft, is preferable to feathers."

"Why so, papa?"

"Because the heat, which gradually collects around a person sleeping on a feather bed, cannot pass away, on account of the bed closing around him; thus, you see, more warmth is generated than is healthful."

"I think, papa, that I prefer a feather bed to a wool mattress, for my own use," said Emily.

"I have no doubt you do, and you are not the only one; but there is no doubt you are sacrificing your health to luxury."

"Then you think, papa, that a wool mattress is preferable to a feather bed, in point of health, but why should it be?"

"I think that mattresses are preferable when we have a sufficiency of bed clothes. I always feel far more refreshed by sleeping on a wool mattress, than I used to do by sleeping on a feather bed; but, you know that every one has a right to follow his own inclination in these matters."

CHAPTER XIII.

VENTILATION.

Bed clothes—Bed-curtains and their effects—Why first used —Impure air—Human breath will poison small animals—The cause of stupor and headaches in the morning—Remedies for dullness, headaches, nervousness, and languidness—How impure air can be avoided in sleeping apartments—How to ventilate a room—Why damp beds cause illness.

"We will now go on, if you please, where I left off last evening, by saying a word or two about bed-clothes."

"That is the subject," said Emily, "which I wanted to speak to you about, as I never could understand why we place the clothes always in one way."

"I shall feel most happy," said Mr. May, "to explain any of your difficulties, as far as I am able."

"Well, papa, as I do not suppose that you understand exactly how a bed is made, I must tell you. After it has been well shaken, so that there are no lumps, the first thing we do is to lay a blanket; do you know the reason why we do that?"

"You know that a good blanket* is made of wool, and therefore a slow conductor of heat. This serves to prevent the heat of the body from escaping into the bed."

"After the blanket is laid nice and smooth, we then lay the bolster, then the bottom sheet and pillows."

"Yes; in that we practise a great deal of domestic economy."

"In what way, papa?"

"You know that in a short time we are obliged to have a change of sheets, as they get soiled. Which is easiest to wash, a sheet or a blanket?"

"I would sooner wash five sheets than one blanket," said Emily.

"I have no doubt you would. Now, you know why we use sheets; simply because they are more easily washed than blankets."

"The next step, papa, is to lay the top sheet, and then comes a pair of blankets. Why do we put the blankets on the top?"

"To prevent the heat from escaping upwards."

"Sometimes," said Emily, "mamma adds another blanket to each bed in very cold weather. That is to keep us warmer; I suppose that means to retain more of the heat that escapes from our bodies."

"It is."

* Inferior blankets are generally made of wool and Chinese grass, a substance resembling wool, but a good conductor of heat, and consequently the blankets are cold.

"After we have got the blankets laid, and all the things tucked in at the sides to prevent the heat from escaping that way, we then lay on the counterpane."

"Yes, that is generally made of cotton, or some kind of material which is easily washed, as it is laid on to prevent the blankets from getting soiled."

"I really am surprised," said Edwin, "to think that there is so much to learn in such common things. These things would never have occurred to me, I am sure."

"You cannot tell, Edwin; by observation and thinking a great deal can be done which one often thinks surprising."

"If you please, papa, what is the use of bed-curtains?"

"To keep the air away."

"Do you think they are very healthy?"

"No, but the contrary; and nothing tends more to bring on nervous diseases than the use of bed-curtains."

"Then why do people use them?"

"When bedsteads were first invented the walls of the room were often full of cracks, and if a bird could not fly through the crevices in the windows, and a dog creep through or under the door, the house was considered unhealthy; thus you see there were great draughts of air rushing through the rooms, and bed-curtains were used to keep away these draughts. Thus the custom has continued with us

to the present day, although we no longer need them.

"But do you not think that bed-curtains are very healthy?"

"They appear very comfortable, but at the same time when they are drawn round a sleeping person, as I said before, they are very unhealthy."

"In what way?"

"That is rather a difficult question, and which to solve correctly we shall have to rely upon our chemical knowledge.

"Now let us suppose it is winter, and the storm is howling without, the rain and snow is pattering against the window of your bedchamber, every blast seems to chill as it blows, and you fancy the wind is rumbling and moaning in its own wild way, because it cannot get at you to twirl and twist you about. On such a night, on going to bed, what would you do?"

"I know what I should do," said Edwin, "I would see that the window was shut close, then I would pull down the sun-blinds, and then draw the window-curtains; then I would draw the curtains close round the bed, so that not a blink of light or blast of air could get at me, then I would jump into bed, where I should soon fall asleep."

"Now you have placed yourself in this comfortable position we will examine it and see if it is as healthy as it comfortable. You are well aware that during the time which you lie there you must breathe,

and every breath you exhale you render the air in the room more impure. When you have breathed the air for a length of time, it is of a poisonous nature, as I showed you the other day, by putting a mouse into a jar of your own breath.* You saw that the mouse began to show signs of sleepiness, and finally appeared as if it was dead. When the air has been repeatedly breathed in the room, your position is something like the mouse in the jar. The air has become very stupifying, and has a sensible effect upon the blood, causing it to flow more slowly through the system, and therefore throwing you into a dozing stupor, from which you feel no inclination to arouse yourself. When you rise it is often late, and you feel miserably dull and stupid, and, during the operation of dressing, you feel very chilly and cold, and as soon as an opportunity presents itself you get close to a fire. You often have, by way of accompaniment, a headache.

"I have often felt in that manner, papa, when I have shut up my room, but I did not know what was the matter with me. I have often thought it was a sort of illness."

"All the illness which you feel is caused by being obliged to breathe impure air."

"What remedies would you propose for this kind of illness?" said Edwin.

* This experiment was tried on a canary. The cage was suspended from the top of the bed, where a full-grown person was sleeping, the curtains being drawn. In the morning the bird was dead.

"If I had been so foolish as to deprive myself of pure air, and felt symptoms such as I have described, I would sponge myself all over with cold water, and then take a good, brisk walk."

"Why sponge yourself with cold water?" said Emily.

"To close up the pores of the skin, which are very much open."

"How do you know that they are open, as you cannot see them?"

"True, I cannot see them; but I know that they are open, by the rapidity with which the heat is escaping, or I should not feel the sensation of cold."

"Why should you go out to walk in the air?"

"My illness is caused by want of oxygen in the system—I have lost it during the night. Now, if I walk briskly against the wind in all probability I shall soon inhale a plentiful supply of oxygen into the system, which will soon show itself by glowing cheeks and perspiration. I have not the slightest doubt but there is a large amount of illness caused by bad ventilation. Now, let us suppose a person indulging in the way in which you proposed, he soon becomes languid, fretful, peevish and stupid; and if he is a man who knows nothing about chemistry, he fancies that he is really ill, and sends for the doctor. The doctor arrives, feels his pulse, shakes his head, and gravely tells him it is his nerves. He then sends him pills and a bottle of medicine, which he affirms will soon set him on his legs again. The person

does as he is bid, goes to bed, perhaps takes the medicine, and, as every sensible person knows, is now really ill. Now, what is to be done? he feels a headache and loss of appetite, and has an antipathy to all social intercourse. The doctor visits him again, more medicine is administered, and so it goes on till the patient perceives himself weak, and well he may; his limbs were given him to use, and when he ceases to use them they grow weak and feeble."

"If you were the doctor, papa, what remedy would you administer to a patient afflicted in that manner?"

"The most speedy cure would be to make him walk over four miles of ground in an hour."

"Suppose, papa, that did not cure him; what would you then prescribe?"

"A large glass of pure water, and a walk over the same space of ground again."

"Why would you give him a glass of pure water?"

"Because it contains plenty of oxygen, of which he is in search."

"I think, papa," said Edwin, laughing, "you would not get many patients at that rate?"

"I daresay not, few people like simplicity."

"I fear we are sadly digressing from our subject," said Emily. "We were talking about impure air in our bedrooms. If this gas is so injurious, how can we avoid it?"

"Your question is one of great importance to females, and I will answer it in as practical a way

as I can. When I was a boy, it was but little time I was allowed for sleep, as I was obliged to rise early and go to bed late; and, of course, what few hours I spent in sleep I strove to make the best of, as I considered. When I went to bed I always took care to lower the top sash about six or eight inches, and in warm weather even more, so that there was an outlet for the warm and impure air of the room."

"I do not see why the warm air should go out, because the window is open."

"It goes out because it cannot help it. I will explain it to you:—When I first went into the room the air was cool and pure, but when I began to breathe it, together with the warmth of my body, rendered it warm, and it is one of the laws of nature that when a substance is heated it expands; thus, when the air in the room becomes warm it expands, and the open window allows it to escape, while a fresh supply comes in from under the door, through the keyhole, &c.

"I always found that when I opened the window, as described, I awoke refreshed and free from stupor; whereas, if I omitted it, I generally overslept myself."

"I will try it to-night," said Edwin, "and then I hope I shall have less difficulty in rising in the morning."

"Is that the reason why people open their bedroom windows?" said Emily.

"It is to allow the impure air to escape which has been generated during the night."

"Which do you consider is the best method of ventilating a room?"

"Open the windows, both top and bottom, and also the doors, so that the wind may have free play into all parts of the room."

"Is it necessary that sleeping rooms should be ventilated every day?"

"Yes; and the best plan is as soon as you are up in the morning to open the window, and let it remain till near evening, so that the wind may have full play into it all day. In winter, when the air is moist, and there is danger of the bed-clothes becoming damp, the room may be ventilated by putting a fire in the grate; the impure air is then drawn up the chimney. There is nothing so disagreeable as an ill-ventilated bed-room, and nothing conduces more to headaches, ill-temper, and illness."

"I have one question more to ask, papa, and that is about damp beds."

"What about them, Emily?"

"Why do they cause illness to persons who sleep in them?"

"The moisture of the bed absorbs the heat of the body much in the same manner as cold sheets do when we first get into bed; but the evil lies in the fact of the abstraction going on all night, and when the person rises he feels very cold; the pores of his body are open, which allows more heat to escape?"

"What do you suppose is a remedy for sleeping in a damp bed?" said Emily.

"If you know that you have slept in a damp bed, the best thing to do is to change your linen, take a warm bath, and rub yourself perfectly dry; then take a tumbler of hot brandy and water, with as much cayenne pepper as will lie on a fourpenny piece."

"Why should you advise those remedies, papa?"

"The person has, for a number of hours, been losing heat through the skin; now, to supply that demand, he has drawn much of the heat from the interior of his system, and it is that heat which we wish to supply. If he were to go into the cold air as soon as he had risen, the result would be the pores of his body would contract so suddenly and forcibly as to cause fever. Too much care cannot be taken with linen and beds. Depend upon it that damp beds and damp linen are a fruitful source of fevers and other illness."

CHAPTER XIV.

CLOTHING.

The cause of persons perishing with cold—The effect of thin boots—Stockings—Lambswool—Worsted and cotton—Clothes have no heat in themselves—Why worsted or woollen is often worn next the skin—Linen—Woollen cloth—Why loose-fitting garments are the warmest—Why we use lighter clothing in warm weather—Why we take off our upper clothes when we are working hard—Why tight-fitting gloves are always cold.

"Among the common things of this life is our clothing. I have not a doubt that there are many people who do not understand why this garment renders them cool, that warm, and this moderate."

"I do not;" said Edwin, "and I should be happy to hear. Will you tell us to-night?"

"It is the subject to which I wish to call your attention. In our former conversations we have repeatedly spoken of conductors and non-conductors of heat; and in speaking of the philosophy of dress we shall again revert to the subject. I have told you that all bodies, when heated above the natural heat, are constantly giving it out. If I lay a hot ball of iron on the ground it quickly gives out its heat to the air. It is just the same with my body—I am warmer than the air, therefore the air is continually absorb-

ing the heat from me. If I could remedy this by keeping up a supply of heat I should want no clothes; but, as I cannot, I must adopt some plan to prevent the air from absorbing the heat too rapidly."

"Is that the reason why we wear clothing?"

"Yes, if we wore none we should soon be in the same position as the ball of iron. You have heard of persons perishing from cold; the cause was because, from want, or some other cause, they could not supply the heat so fast as the air absorbed it from them."

"How do persons feel when in that condition?"

"They feel faint, and have a strong inclination to sleep; it is caused by the cold stopping the circulation of the blood. Now, to prevent this we must adopt some scheme."

"I suppose," said Edwin, "we want clothes to prevent the heat from escaping from our bodies."

"Yes; but now arises the question, what kinds of clothing are best adapted for this purpose."

"That," said Emily, "depends upon the climate we live in, I suppose?"

"You are right; but for the present we will speak of our own country, which you know is a temperate climate, and very liable to change. We will now examine our principal articles of dress, and see if they will admit of a philosophic examination."

"We will commence with our boots," said Edwin.

"Are you speaking of summer or winter?"

"Winter."

"Then we must have a strong pair, with thick soles."

"Why thick soles?"

"In winter there is a great deal of wet weather, and the damp would find its way through a thin pair of boots, and wet or even damp feet are very uncomfortable and unhealthy."

"Why are damp feet unhealthy?"

"When the damp has penetrated through the leather of your boots, there is a communication opened between your feet and the damp ground; the warmth of your feet is absorbed by the moisture which is getting into your shoes."

"I have seen," said Emily, "persons in winter walking without shoes or stockings."

"No doubt you have; and if you could have examined their feet, you would have found them covered with a hard, horny skin, which is far better adapted to keep them warm than your boots."

"I perceive, then," said Edwin, "if we wish to preserve our health in winter, it is necessary for us to have good strong boots."

"What kind of stockings would you prefer?" said Emily.

"As it is winter we shall want what is called a warm pair, that is, a pair which is a bad conductor of heat."

"Worsted stockings would suit us, I suppose," said Edwin, "as worsted is made of wool."

"Worsted is generally made from coarse wool,

therefore I can find a better substance for winter stockings than worsted."

"What is that?" said Edwin.

"Lamb's-wool is softer and warmer than worsted."

"I suppose you mean to say that lamb's-wool is not so good a conductor of heat as worsted, and consequently retains more heat?"

"Yes, papa, that is my meaning."

"Then we must have a pair of lamb's-wool stockings, I suppose, if we wish to be warm and comfortable; but if we cannot afford lamb's-wool we must be content with worsted, which will last much longer."

"I always considered," said Edwin, "that it was the clothing that was warm; but now I perceive that the clothes only keep the heat of our bodies from escaping."

"That is the purpose of clothes; they have no heat in themselves."

"I think," said Edwin, "I now understand why people often wear woollen next the skin."

"Why?"

"Because in the first place it retains the heat of the body, and, if by any means the body gets more than usually heated, it does not allow the heat to pass away so rapidly."

"The next question is why people always wear linen next to the flannels, and in some cases next the body."

"No, papa, I do not think I can tell," said Emily.

"I can," said Edwin; "it is like the sheets, of

which we were speaking the other evening; it is a point of economy. The body is continually giving out perspiration, which is absorbed by the garments next the skin, and would in a very short time render them very offensive, unless they were renewed very often. Linen is more easy to wash than many other things would be, and therefore it is chosen for that purpose."

"Thank you, Edwin; it seems that you now understand the subject. I have another question to ask, and that is, of what materials ought our garments to be made, so as to render them serviceable for winter?"

"Good woollen cloth, as that retains the heat much better than any other substance."

"I should not say that woollen cloth retains the heat better than any other substance—it does retain the heat, and is also a very convenient material for that purpose. How would you have your clothing to fit you, tightly or loosely?"

"I think moderately tight, as it looks the neatest."

"I have no doubt but they look neater, as you observe, when they fit tightly, but loose-fitting garments are the warmest."

"I do not understand that," said Edwin.

"I will explain it to you. In garments that fit loosely, there is a space between the body and the clothes; this space is full of warm air which the garments retain. Thus, you see, when our clothes

fit us loosely, we move about as it were in an atmosphere of warm air. If our clothes fit us tightly there is no room for this air, and consequently there is not so much warm air near the body."

"I understand now," said Edwin, "why we button our jackets and coats when we feel cold."

"So do I," said Emily; "it is to keep us warm."

"Yes, Emily, that is the common term; but in reality it is to retain the heat which is escaping too rapidly."

"It seems like turning a tap to prevent a fluid from escaping too fastly."

"It is something like it; for, as soon as we have again got up a supply, we can again let it out by loosening our clothes."

"Now, let us suppose that winter has passed away; the sun begins to shine, and as the air grows warm, our winter clothing begin to get too hot, that is, the heat does not escape so fast as it is generated, therefore it renders us uncomfortable; under those circumstances what do we do?"

"We put off our winter dresses, and put on cooler."

"What do you mean by cooler dresses, Edwin?

"Those that conduct the heat, or allow the heat to escape more rapidly. Cotton garments, I should suppose, are well adapted for that purpose."

"You must remember, that as yet it is a very changeable season of the year; to-day it may be warm, and to-morrow cold, so that too sudden a

change would not do, we must have something more suitable than cotton."

"What do you think is best?"

"There is a cloth that is a mixture, of both wool and cotton; this is very suitable for spring, as it retains the heat, but gives it out more readily than woollen cloth would do. Now, let us suppose that the warm season of July and August are come, when the air is sultry and hot, the warm air by which we are surrounded cannot convey the heat away so fastly through our cloth garments as it is generated; therefore we must put on garments that readily allow the heat to escape, which are mostly made up of cotton and wool. I think now you understand the philosophy of dress; but if you have any questions to ask before we close the conversation, I shall feel great pleasure in answering them."

"Why do men strip off their clothes, when they are working hard?" said Edwin.

"When men are exerting themselves very much, heat is generated much faster; and they put off their upper clothing to let it escape."

"Why is a tight-fitting glove more cold than a loose one?"

"Because there is not room between the hand and the glove for warm air, and thus the heat is conveyed directly from the hand through the glove."

"Why are kid gloves difficult to get on a warm hand."

"I suppose when you purchase a pair of kid gloves you always take care to have them small enough, as they are apt to stretch when you have worn them a few times. You consider that they fit you if you can but get them on by any means when the hand is cool. Now, when your hand is warmer than usual the heat causes it to expand, and at the same time it is damp with perspiration; thus you have two obstacles to overcome, the expansion of the hand and the perspiration.

CHAPTER XV.

BOILING WATER.

Meaning of the term boil—The process which takes place when water is boiling—Why the water in the kettle boils over—Why the water ceases to boil when the kettle lid is raised—Why the kettle sings—What is hard water—Why the kettle suddenly ceases to boil when taken from the fire—Difference between hard and soft water—Why soft water makes better tea than hard water—Why clay vessels hold the heat longer than metal—The cause of the rushing noise in steam engines.

"I THINK, papa, you will smile when I tell you what I have been about since our last conversation."

"What is it, Emily?"

"I have been watching the kettle boil."

"I am glad to hear that our conversations have led you to observe the things around you; and besides it was by watching the kettle boil that James Watt had the first idea of the power of steam; so that you see that your employment has not been so very ridiculous. Now tell me what observations you made."

"I did not make any observations, papa; and, although I have seen the kettle boil many times before, I really do not understand why it should boil."

"I shall feel great pleasure in explaining the operation to you. We will suppose that the kettle has just been hung over the fire."

"Will you please first to explain the term boil?"

"By the term boil, I mean putting as much heat into the water as will raise the heat up to 212 degrees: we can heat it no higher. If we were to put a thermometer in the midst of a thousand gallons of boiling water, and then into a boiling kettle, we should find the degree of heat exactly the same. If we still add heat to it, the water gets no hotter, but goes off into steam."

"I do not understand why the water rolls and bubbles about in the way it does when it is hot."

"I understand what you mean, and I think if you will have a little patience I shall have no difficulty in making you understand it. We have supposed that the kettle is put over the fire to boil filled with cold water. The first thing which warms is the metal at the bottom of the kettle, which communicates the heat to the lowest particles of water, which form small bubbles of steam on the bottom of the kettle; these continue to enlarge till they are about the size of a pin's head, when they try to rise to the surface; but coming into contact with the cold water above, the heat is absorbed from the steam, and thus they again form water. As soon as the first bubbles of steam leave the bottom, more cold water falls into their places, which is again converted into steam, which rises in the water, and again is deprived of its

heat by the cold water. Thus the process goes on; the water at the bottom of the kettle getting hotter—the steam forming in proportion. As the water warms, the small bubbles of steam are obliged to ascend higher every time, till at last they ascend to the top. When the steam generates faster than it can fairly rise to the surface, or the water is heated to about 212 degrees of heat, the steam then rises so rapidly that it forces the water up with it. We then say it boils."

"Then we are to understand," said Edwin, "that it is the rapid rising of the steam from the bottom of the kettle to the top which causes the water to roll about, when we say that the kettle boils."

"What is the reason that it stops boiling," said Emily, "when we raise the lid?"

"When you take off the kettle lid, you let in a quantity of cold air, which rapidly absorbs heat from the water; those particles which have lost heat contract and immediately fall, absorbing heat from the hot water around them—thus reducing the temperature. If, when the water is boiling, you thrust a piece of cold iron into the kettle—as the round ball at the end of the poker—it will immediately cause the water to cease boiling."

"Why is that, papa?"

"Because the iron is cold, and absorbs the heat from the water."

"I have often noticed," said Edwin, "when the kettle has been put over the fire for a short time

there is a singing noise, or we say that the kettle sings. What is the cause of that, papa?"

"Water, as I have before told you, is composed of small globular particles. Now, between every one of these there is a space. In pure water these spaces are full of air; but in all natural water they are more or less full of matter which it holds in solution, such as salts, oxide of iron, lime, magnesia, &c., which the water collects as it flows along. When there is a large portion of the two latter in it, we say the water is hard. When the water is placed over the fire, as soon as it begins to get a little warm the air between these particles expands and escapes, and the singing noise which we hear is the air escaping."

"You have shown us, papa, why the water stops boiling when we take the lid off; will you be kind enough to tell us why it stops boiling when we take it from the fire?"

"As soon as the kettle is removed from the fire, the stream of heat not only ceases going into the kettle, but the bottom of the kettle actually begins to give out heat, and therefore the boiling point is instantly reduced. It is remarkable to see how quickly the effect of cutting off the stream of heat has upon the whole body of water,—how almost instantaneously the boiling ceases."

"I have often heard you and mamma say that you can tell by the look of the tea or coffee whether it is made of hard water or soft. How can you tell that?"

"I told you that all natural water contained more or less of foreign substances; now, when these spaces are full, they cannot hold the particles of tea, therefore the tea looks pale and weak. If we take soft water, and the same quantity of tea, we shall see a very marked difference; the spaces in soft water being comparatively empty, therefore there is room to take in the particles of tea. I have no doubt you have heard the saying 'that a pint of spring water will make better tea than a quart of pump water.' The case might be applied to soft and hard water, and we may say that a pint of soft water will make better tea than a pint of hard." "I was in the kitchen the other day, and I saw the cook take out of the oven a large earthenware basin, full of boiling water, and I noticed that it boiled for a minute after it was taken out of the oven. Do you know the reason of that?

"No papa, I cannot say I do; perhaps you will be kind enough to tell me?"

"First, you must tell me what the basin was made of."

"Clay, I suppose."

"Yes, and that proves to you that clay holds the heat, or is not so good a conductor of heat as metal. If a stone bottle, as they are termed, is filled with boiling water, and wrapped round with a flannel, it will hold the heat for twenty hours, and at the end of that time, the water will be so hot as not to allow the hand to be held in it. In this case, the water,

the bottle, and the flannel are bad conductors of heat. When the water is boiling, you see the vapour issuing very rapidly from the lid or spout; this vapour is composed of small particles of water and steam, rushing against each other in the rapidity of their flight."

"Is that the reason why steam-engines make such a roaring and puffing noise?"

"There is no doubt of it; but in the case of a steam-engine the rarified air and vapour from the funnel, striking against the air, cause the noise which we hear.

CHAPTER XVI.

THE AIR.

The general properties of the air—the wisdom of the Creator, as shown in the transparency of the air—The pressure of the air—How we know that the air presses equally in all directions—The leather sucker—Why water can be drawn up a tube—How we know that the air presses upwards as well as downwards—How snails and caterpillars are supported when climbing—Curious fact with regard to snails, the horseleech, and the remora—How oysters and mussels keep their shells closed—The cause of the pressure of the air—The air has weight—Why we do not perceive the weight—How we can find that the air has weight—The elasticity of the air—How it can be proved that the air is elastic—Compression—The pop-gun—The wonders of the air—The beauty of God's handiwork.

"Our subject," said Mr. May, "for this evening's conversation will be the air we breathe, as it is one of the most common, and also one of the most important for the well-being of all terrestrial creatures."

"Will you tell us, papa, what are the general properties of the air?"

"I shall feel great pleasure in so doing; but at the same time, when I speak of the properties of the air, you must not only remember that these properties are certain mechanical actions; but I want you to see them as great and mighty agents of God, a sort of ministering servants, whose duties are to

confer happiness on all earthly creatures. If we do not see, in these great works, the wisdom and design of the Great Creator, it will be in vain for us to look into the great book of nature. Suppose I were to take you to see a beautiful machine at work, but it so happed that you could only see a very small part of it at once, and I was to say that is a wheel, that is a strap, and that is a chain. Now, you would come away with a very confused idea of the wonderful machine. Just so it will be if we only see in our examination of the air those certain mechanical properties of which I shall now speak."

"What are the general properties of the air?" said Edwin.

"I will give you a list of them, and then you can copy them out. 1. It is transparent; 2, it presses equally in all directions; 3, it has weight; 4, elasticity; 5, compression. These are the chief properties of the air we breathe. There are others, of which we shall speak when we come to speak of its chemical properties."

"What is the meaning of the word transparent, as used here?" said Emily.

"Anything through which light will pass; such as air, glass, water, &c. In this one property alone we cannot fail to see the wisdom of an All-wise Creator. If we could suppose that the air had not been transparent, what a miserable existence ours would have been, if we could even have existed at all; without the transparency of the air, our eyes

would have been perfectly useless. If we can for a moment conceive the idea of the whole of the human race deprived at once of their sight, or the air losing its transparency, we could then form some idea of what a miserable and useless life ours would be. Man nor animals could not exist. How little are we aware of the thousands of mercies by which we are surrounded!"

"What do you mean, papa," said Edwin, "when we say that the air has a pressure?"

"I mean that it presses equally in all directions."

"This is owing to its weight."

"How do you know that the air presses equally in all directions?"

"I think I have seen you and Edwin playing with his leather sucker."

"You mean, papa, that round piece of leather with a string through it, which he puts into the water?"

"Yes."

"Edwin and I have often played with that, but we never could understand what it could possibly be that caused it to adhere to the water."

"When he puts the sucker into the water there is no air beneath it, so that when he pulls it to the surface, it has the pressure or weight of the air upon it, and it is that which causes it to stick to the water. A very curious experiment may be tried with it, if you take a small quantity of water in a small tin vessel and dip the sucker in it, you may lift up both the

water and vessel at the same time. The other day I saw Edwin drinking through a pipe."

"Yes, papa, but I could not understand how it was that the water came into my mouth."

"When you put the pipe into the water it was full of air; but as soon as you drew the air out of the pipe the pressure of the air outside pressed the water up the pipe, where there otherwise would have been a vacuum. These two facts show that the air presses downwards."

"I do not think, papa, that I see any uses of the air pressing downwards; but I am sure there are, or it would not be so."

"If the air did not press downwards, although we might raise the water to our lips, we should not be able to drink. In fact, we could not get water into our mouths, except by such means as a spoon. Thus you see that nearly the whole of the animal world would perish, although the water was up to their knees, if it was not for the pressure of the air downwards."

"I think I understand you, papa; but how can you show us that it presses upwards?"

"Do you remember asking me last summer how it was that the flies managed to walk on the ceiling?"

"Yes, papa, I remember it quite well, and you said it was owing to the pressure of the air; but I cannot say that I thoroughly understand it; perhaps you will be good enough to explain it again."

"If we were to examine a fly's foot, we should see that it somewhat resembled Edwin's sucker, only it

is a great deal softer. When the fly alights on the wall, it spreads out its broad, sucker-like feet on the wall, taking care to have no air beneath them; the weight of its body then tries to pull these suckers away from the wall, and, in so doing, forms little vacuums under them; thus the pressure of the air is greater outside the foot than under it, and by that means the fly is borne up. This shows that the air has a pressure upwards."

"I understand you very well, papa," said Emily; "but how can you show us that it has a lateral or side pressure?"

"You have seen caterpillars climbing up cabbages, I suppose, and up posts?"

"Yes, many times," said Edwin.

"Their feet are formed almost like the fly's, and they are supported by the pressure of the air. You have seen snails creeping up a tree."

"I saw, yesterday, in a hole in a tree, a large bunch of them sticking together, and I intended asking you how they were able to stick together, as some were hanging downwards, some sticking sideways, some resting on the top, and a number of them adhering to the wood."

"I am glad you mentioned that fact, as it will assist me in showing that the air presses equally in all directions. The snail, like the caterpillar and fly, has the power of forming a vacuum, and by that means they are able to stick to anything. You say that the snails were sticking to each other in all

manner of ways. In that fact alone we can see that the air presses equally in all directions. If it only pressed upwards or downwards, the snail could not adhere to an upright post. It is a curious fact, and, as far as I am aware, it is the only creature that moves itself along by means of the pressure of the air. It has also the power of exuding a kind of matter, which helps to render the surface upon which it is climbing more smooth, and it also helps to enable it to form a more complete vacuum. If you see a large snail ascending a tree, and you put the point of a knife under it, it falls in a moment, which shows us that the creature has no power to hold on to the wood except by means of the vacuum."

"Are there any other creatures which can support themselves by means of a vacuum?"

"Yes, the horse-leech will stick itself so firmly to a piece of glass that they will almost bear to be pulled asunder before they will let go. There is also a kind of fish, called the 'Remora,' which will attach itself to the whale; and they have also been found sticking to the bottoms and sides of ships. The oyster and mussel keep their shells, in a great measure, closed by means of the pressure of the air. If you were to make a hole through the shell of an oyster, there would be no difficulty in opening it. I dare say you have noticed that when the fishmonger has inserted the point of his knife and let in the air, the oyster has no more power to close it, simply because the shell is injured, and it cannot make a vacuum in the shell."

"What is the cause of the pressure of the air?" said Edwin.

"The air which surrounds our globe is about forty-five miles in height, and, as all matter is attracted by the earth, so air is also acted upon by the attraction, which gives it a weight of about fourteen pounds upon every square inch of surface; but as we ascend in the atmosphere the pressure becomes less. By way of illustration, let us suppose a large number of bricks piled one above another, to a great height, the top one will have the least pressure, but the next would have the weight of the top one, and each succeeding brick would have a heavier weight than the one above it, and thus you see the bottom one would have the greatest weight upon it. So it is with the air, the higher parts press upon the lower, which is the cause of the great pressure I have been attempting to describe to you.

"I understand what you mean, papa; but can you tell me of what use this great pressure in the air is?"

"I am glad you have asked this question, as it was my intention to have said a few words about it. If it was not for the pressure of the air, as I showed you, we could not drink; now I can tell you further that we could not breathe if it was not for the pressure of the air. Most persons think that, when they breathe, they draw the air into the lungs, but such is not the case. We drive the air out of our lungs, and the moment it is expelled, and we open

them again, the air rushes in, which we again expel; but if the air was not pressed into our nostrils and lungs we should not have the slightest power to obtain it. Thus, my children, you see how wonderfully the air is adapted for the purpose of breathing. If it were not so, and we had to go in search of a supply of air, as we do of water, how miserable we should be; but you see how wisely the all-wise Creator has adapted it to our wants, even forcing it upon us by its immense pressure."

"I think I understand the uses of the pressure; but how can it be proved that the air has weight, as it does not seem to have?"

"You are right, it does not seem to our faculties to have any weight whatever. If you take a bucket and lower it into a well by means of a cord, and let it sink to the bottom, although it is full of water when you begin to raise it from the bottom of the well, yet you do not perceive the weight till the bucket begins to rise above the surface. It is the same with air; we do not perceive its weight, because we are surrounded by it. It must be evident that, if the air has a pressure of fourteen pounds on every square inch, there must be weight to cause the pressure. It can also be shown that if a vessel which held a quart is exhausted of the air and then balanced on a very fine balance, it will be found, when the air is let into the vessel again, to increase in weight about fourteen and a quarter grains; but this weight differs, as the air is seldom two days together

in the same condition. I think we may show in another way that the air has weight. You have seen a piece of wood thrown into water?"

"Yes, many times."

"What happened to the wood?"

"It floated on the surface of the water."

"But why did it float?"

"Because it was lighter than an equal bulk of water."

"Yes. Did you ever see anything in the air?"

"Yes, smoke."

"But why does smoke rise in the air?"

"For the same reason that the wood floated in the water; because the smoke is lighter than the air, or in other words, the air is heavier than the smoke."

"But can an object be heavy without weight?"

"Certainly not, papa."

"Then we may conclude that the air has a great pressure, and that pressure is caused by its weight."

"What is meant by the elasticity of the air?"

"It means that it is capable of being expanded and then contracted again."

"How is that shown?"

"It may be shown by this bladder, which is half full of air. If I place it near the fire, it immediately causes it to expand. I now take it away, and you see it sinks to its original size. If I were to put this bladder under the receiver of an air pump and remove the air around it, the air in the bladder

would begin to expand till the bladder burst, if there were room enough in the receiver for it to expand; but the moment the air is let into the receiver, the air in the bladder again contracts to its natural size. It is said by philosophers that if all the air which surrounds the globe were to be annihilated with the exception of one cubic inch, if that inch were at liberty it would immediately spread over the whole surface of the globe."

"What is meant by compression?"

"It means that a certain portion of air in its natural state can be compressed into a very small space. This can be illustrated by Edwin's pop-gun. When you put the pellet into the tube, the tube is full of air. When you drive up the stick, you compress the air in the tube, which causes it to act like a spring, which causes the pellet to fly out. This is a very simple method of illustrating the subject, but with a costly apparatus air can be compressed several thousand times; that is, several thousand gallons of natural air can be got into a space in which there is room for only one gallon of natural air.

"Now, let us look at the properties of the air in another point of view. We have looked at the fact of its being transparent, and we then saw how miserable would have been the fate of the animal world without it. Now we will hastily glance at its other properties.

"Let us try and suppose that the air was devoid

of those properties which we have been examining, and we shall see what our globe would be like. If there were no pressure and elasticity, every breath we breathe would create a vacuum; and, instead of having it forced upon us by the pressure upon it, we should have to go in search of it. How could the animal world exist if such were the case? If the air had no pressure and elasticity, all our fires would cease to burn. No power in which we are at present in possession could keep them alight; and then where would be the end of it? All culinary operations would be at an end, all the arts and manufactures must cease, and we should be in the state of those savages of whom you may have read, who have no knowledge of fire. Neither would this evil rest only with the arts. Without the pressure and elasticity of the air, the winds would cease to blow, evaporation would cease, and there would be neither dew nor rain; and for want of winds the trees could not obtain a supply of carbonic gas, which is so essential to them. The climate would be materially affected: we should also live almost in twilight, if it were not for the pressure of the air. Could we exist under those circumstances? Could all those beauties of the creation have been brought into existence but for these wonderful arrangements of the All-wise Creator? We can see at a glance, that if only one of these properties of the air (insignificant as they may appear to a careless observer) had been omitted by the Creator, as far as human

knowledge can show, the globe would have been a mass of useless matter. But, instead of that, we find every thing prepared for a certain end, and that end is the happiness of God's creatures. Again, if we examine the nature of animals and vegetables, we shall see equal wisdom manifested. What use would the transparency of the air have been if we had been created without eyes? Thus you see how beautifully one thing arranges itself with another; or of what use would the oxygen of the air have been if animals had not the power of receiving it, or what would have been the use of the carbon or food which we take in without the oxygen? Take them separately, and they are useless. Then again, what would have been the use of the combination of the oxygen and the carbon, as in carbonic acid, if the plants had not been prepared to absorb it? We might go on showing how all things were created for a wise purpose, and, like the wheels of a beautiful machine, all work in harmony, and are so prepared that not a particle of matter can by any means deviate from the course which nature has intended it to pursue.

"What a mind that must be who could see all those mighty operations in nature at work, in idea, before they were called into existence. From the lowest animal, so small that hundreds of them can swim with ease through the eye of a needle at the same time, to the largest monster that walks the earth or swims the deep, all had to be planned, and physi-

cally arranged for the purpose that they were designed to fulfil. How beautifully are the tender mercies of the Creator here exemplified, in creating all these myriads of living creatures so perfectly that their lives seem, for the most part, all pleasure and and happiness. How wise, then, those physical arrangements of the animal world that can produce such results. How small is even this when compared with the vast extent of the universe? To our conception, we think a mind must be great to plan a world, with all its numerous laws, creatures, &c.; but how infinitely greater must that mind be to grasp the plan of a boundless universe? It has been said by a celebrated writer*—'If we could stand upon the farthest star the most powerful telescope is able to show us, and again apply our telescope, we should, without a doubt, see stars far beyond; and even if we could but go to those stars, we should not even then reach the threshold of the Deity.' Such is the power and mind of God, my children; and I trust when you address Him again in His house, in the words of 'Almighty and most merciful Father,' you will do so with some idea of what Almighty means. Yet, children, He has commanded us to address Him as 'Our Father.'"

* Addison.

CHAPTER XVII.

THE CHEMISTRY OF THE AIR.

Simple elements—Oxygen and nitrogen—The composition of the air—Carbonic acid—How it is produced—How plants under water obtain carbonic acid—Why trees thrive more luxuriantly by a lake than those at a distance—How the physical features of the globe are changed—How rocks are formed at the bottom of the ocean—The manner in which the air is purified—The course of a particle of carbonic acid—Oxygen—Its uses—Why people eat pickles, salads, and vinegar, in hot weather—The reason that fat meats are distasteful to us in hot weather—Why such vast quantities of oysters are eaten in poor neighbourhoods—The reason that we require more food in winter than in summer—Why man is a creature of all climates—The reason that the Esquimaux will eat the fat of the seal—The reason that rice is the chief food of the people in hot climates.

"We now come to another part of our subject, and I have no doubt as we proceed we shall find it equally as wonderful as that which we have already gone over. To the eye of a common observer the air seems to be a pure and simple element."

"What are we to understand by simple element?" said Emily.

"'Simple element' is a term used in chemistry to distinguish from compounds. I will explain it to you. Let us take a piece of bright iron, which is a

simple element—that is, it is iron, and nothing more—and dip it into water; in a short time it is covered with rust. The rust is not a simple element, but a compound of the oxygen of the water and the iron. Oxygen and hydrogen, by themselves, are simple elements, but, when chemically mixed, they form a compound, which is water. Soda and tallow or fat mixed together in hot water form soap.

"I think I understand you," said Emily; "when the substance cannot be any longer chemically divided, it is then called a simple element."

"Yes. In the air we have the elements mechanically mixed."

"How many substances or elements are there to compose what is called the atmosphere?"

"The great bulk of the atmosphere is composed of two gases, oxygen and nitrogen; but besides these, there are several ingredients, such as carbonic acid, watery vapour, electricity, nitric acid, &c., but our attention will be directed more particularly to the first three."

"Are the three gases mixed equally?"

"No; nitrogen and oxygen are mixed in the proportion of about one part of oxygen to four of nitrogen. If we take a hundred gallons of air, and subject it to analysis, we shall find nearly twenty-one gallons of oxygen and seventy-nine of nitrogen; but if we take a thousand gallons of it, we shall find not only the oxygen and nitrogen, but we shall also find one gallon of carbonic acid?"

"Is carbonic acid an element of the air?"

"No, not exactly, although the air would be useless in supporting plants without it; but it comes there accidentally as it were."

"How is it produced if it is not a natural element?"

"The carbonic acid which is found in the air is formed during the process of combustion or burning, breathing, and the decaying of animal and vegetable matter; the carbon during these several processes unites with the oxygen, and forms the substance we call carbonic acid."

"In a former conversation you stated," said Edwin, "that the plants and trees absorbed the carbonic acid; if such is the fact how do plants under water obtain it?"

"The water absorbs the gas from the air, and as it flows along in the rivers and brooks, the gas is absorbed by the plants. But plants which grow in water, as at the bottom of rivers, ponds, ditches, &c., do not contain so much carbon as plants that grow on land; they have no need of it, as the water supports them. Did you ever notice when weeds have been pulled out of a river, how soft and weak they are, and after being exposed to the sun for a short time, they nearly all vanish. This is because they have but little carbon or woody matter about them."

"Papa," said Edwin, "I think I made a discovery yesterday, but I am not sure."

"It is best, Edwin, not to be too sure, as some one may have discovered it before you; but let us know what it is."

"Yesterday, as I was coming home through the fields by the lake, I noticed that in the old avenue in the park, on both sides of the lake, the trees were much larger than in any other part of the avenue; and I could not help noticing how luxuriant the branches appeared, and in fact they looked quite dark, compared with those further from the lake."

"Well, Edwin, and what of that? I have seen the same thing over and over again for the last ten years."

"What I want to know," said Edwin, "is why the trees are so fine and luxuriant by the lake?"

"I think I can solve that question," said Emily.

"Let us hear it then," said Edwin.

"Papa has just said that water absorbs carbonic acid; may not the water of the lake attract the carbonic acid, and as it is drawn towards the water the trees obstruct it, and by that means get a larger supply than those at a distance?"

"Is this the discovery you spoke of, Edwin?"

"Yes, papa."

"It really does seem very likely; but there is also another cause of their being larger, and that is they get more nutriment from the earth by being so near the water. Perhaps the two causes together may produce the effect of which you speak."

"Is carbonic acid of any other use in nature, besides supporting vegetable life?"

"Yes; it is one of the great agents of nature in changing the physical features of the globe."

"In what way?"

"I think I shall be able to make you understand it, by the following experiment. This glass is full of lime water."

"What is lime water?" said Emily.

"It is distilled water, in which I have put some lime, and when it becomes clear I poured it from the lime, and here it is. Now I take this lime water in which there are some particles of lime, and blow in it through this tube. You now perceive that my breath has turned the water to a milky colour."

"What is the cause of the change?" said Edwin.

"In the water which appeared clear and sparkling, there were small particlcs of lime, and when I blew into the water I blew carbonic acid, which immediately united with the lime, and formed small flakes of chalk. If you notice it, you may see the small flakes uniting together, and are sinking gradually to the bottom of the glass.

"I understand the experiment," said Edwin, "but I cannot see how it can alter the face of the globe."

"I shall speak of that presently. By this experiment I wished to show you that carbonic acid and lime have an affinity for each other. I have before observed that water absorbs carbonic acid; now it so

happens that lime is one of the constituents of the ocean; thus you see when the lime and carbonic acid meet together in the water, they unite and fall to the bottom of the ocean, forming chalk, limestone, marble, alabaster, and several other different kinds stones and rocks. In the course of ages, by these means, large tracts of the ocean are filled up, and the waters are driven to other parts."

"It appears," said Emily; "that not only are vegetables great purifiers of the atmosphere, but the ocean also assists in a great measure."

"You are right, Emily, and very curious it appears when the elements of matter are decomposed and are no longer of use, the ocean forms a receptacle for them, keeping them as it were in a large storehouse, till millions of years have passed away, and they come into use again in the shape of rocks and stones of various kinds.

"If we were to take a geological survey of England, I have no doubt that we should find that three-fourths of the rocks have been formed in this manner. Nearly the whole of the hills of England are composed of lime, carbonic acid, sand, and a few other elements. Thus we may say that, had it not been for carbonic acid, the island on which we live would never have existed.

"I do not think," said Edwin, "that I clearly understand how stone, &c., is formed."

"Common building stone is formed of lime, carbonic acid, and sand. The carbonic acid was formed

on land, and was absorbed by the ocean, where it united with the lime, fell to the bottom, became mixed with sand, and became chemically united, in the same manner as mortar, and, finally, hardened by the tremendous pressure of the water above it."

"I really feel," said Edwin, "more surprise at every step we take in our views of nature. How little did I think before this evening that the air I polluted with breathing went to assist in bringing forests into existence for the use of unborn generations, hundreds of years to come."

"You are right, Edwin; or it may help to form rocks which may lie at the bottom of the ocean for millions of years, and then be heaved up, and form new islands, while those now in existence may lie many fathoms below the surface of the sea. Before we lay aside this interesting subject, let us try to trace a portion of carbonic acid through the course it might pursue. Let us suppose that a portion of it is floating in the air; it gets absorbed by an oak tree, where it may exist for five hundred years before the tree is cut down. It then gets into the hands of a builder and worked into some large building where it may last for three hundred years more; but in time oak will decay, and the wood at length comes to the fire, and our carbonic acid is again free. Where will it now fly to? Perhaps to a forest, and thus take the same round again; or it may go to form a vegetable, which may be eaten by an ox, and thus it

goes to form a part of it; the ocean may absorb it, and it may rest in undisturbed repose for millions of years, but even at the end of that time that particle of carbon is not lost, but is as perfect as on the day it was created. This is the way in which nature works; to our minds it may appear slow, but it is undeviating. Thus nature rolls on the same round over and over again, the same elements forming the same materials through all the countless ages in which the world has existed."

"You said, papa, that we use oxygen when we breathe, what effect does that have upon us?"

"It may be called the mainspring of our lives; for it is upon that we partly depend for our bodily heat, health, and spirits. It is oxygen which assists to convert our food into blood, and sends it purified through our arteries and veins."

"I have often observed," said Edwin, "in very warm weather, how distasteful fat meat is to us, and how pleasant such things as pickles, vinegar, and salads are to us; but I never could understand the reason of it."

"Your observations are just, and the solving of the question depends wholly upon the subject of which we are now speaking. In summer, when the weather is very warm, the air is more rarefied, or thinner, and consequently, when we breathe on a warm day we do not take in so much air as we do on a cold day, when the air is more dense. Thus you see when the weather is very warm we do not

get so much oxygen into our system as we do in winter; therefore we do not want so much carbon, or food, to mix with it. That is the reason we do not like fat meat in hot weather. It is a wise arrangement that we do not; for, if we were to eat a quantity of fat meat, it would render us very dull and sleepy, our blood would soon become overcharged with carbon, and would produce faintness and death. On the other hand, let us suppose there is as much oxygen in the air in summer as in winter, we should then have as much relish for fat meat in summer as in winter, and what would be the consequence? What with the heat of the weather, and the heat engendered in our system, we should be so hot that we should be very miserable, if not delirious. With regard to the last part of your question, concerning our relish for salads, fruits, &c., in warm weather, it depends upon the heat of the weather. If it is very warm and we take in but little oxygen, we feel a desire to supply it by artificial means, and consequently feel desirous of partaking of those things which contain it, as fruit, vinegar, pickles, &c. The food which we most relish in cold weather, as different kinds of fat or carbon, we feel but little inclination for in summer, unless it is accompanied with oxygen in some shape or another."

"I have often seen," said Edwin, "men stand with fruit for sale near to the large ironworks; and if it has been a warm day I have noticed how eagerly the men purchase sour apples, gooseberries, or

oranges. I suppose the reason of it depends upon their natural oxygen?"

"It does; I have often noticed the same thing myself. The reason that these men have such a relish for sour fruit is, their workshops in summer are very warm, and consequently the air is very rare, and they do not get so much oxygen as the system requires, therefore they strive to get it artificially. I once heard a very intelligent man say, who worked in an iron foundry, that he always drank a pint of vinegar in a day, diluted with water, and he considered it one of the most refreshing drinks he could take. Another man, who was employed in a factory where there was a great amount of heat, said that he believed, besides vinegar, he drank annually a gallon of vitriol. Such is the craving which these men feel for oxygen, when a sufficient supply cannot be obtained from the air they breathe."

"I have heard, papa, that there are more oysters eaten in the eastern part of London in proportion, than in any other town in England. How is that accounted for?"

"Simply for the reasons above stated. People eat them with vinegar, which is to supply the want of natural oxygen. It is a wonderful fact, that the poorer and the more densely crowded the people are, the more oysters they seem to eat."

"How is it that we require more food in winter than in summer?"

"The case is exactly the reverse of what I have just stated. In winter, when the weather is cold,

the air is very dense, and consequently we take in more oxygen every time we breathe; and the more oxygen we take in the more carbon, or food, we want to mix with it. This accounts for the fact that the colder the weather the more food we want; but we have no desire for lettuces, radishes, or other salads, but something in which there is plenty of carbon."

"I remember," said Edwin, "when I was in Cambridgeshire, they always told me to eat all I could to keep the cold out. Do you think it really did?"

"The food of which you partook did not keep the cold out of the system exactly as the farmer meant, but it certainly assisted to produce a great amount of heat."

"Is it," said Emily, "through our taking in so much oxygen and carbon that we are enabled to endure the cold?"

"It is."

"Then that solves a difficulty," said Edwin, "that I could not before get over."

"What is that Edwin?"

"Do you remember our reading that man was a creature of all climates, that he could endure the intense cold which would freeze quicksilver, and he could also subsist under the burning sun in the torrid zone, where the heat is sometimes sufficient to boil spirits of wine."

"Yes, I remember reading it perfectly well, and I am happy to hear that you now understand how

it is that man is able to live in such extremes of climate."

"I do not think I understand it," said Emily, "will you be kind enough to explain it to me?"

"After what has been said about oxygen and carbon, I think that you will have little difficulty in understanding this last question. In those regions which in winter are intensely cold, man and other animals can live and enjoy good health and spirits. You must remember the more intense the cold, the more dense is the air, and man takes in a larger supply of oxygen, therefore he requires a greater amount of carbon or food to mix with it. Now, Edwin, can you tell me what the Esquimaux usually subsist upon during the winter?"

"The flesh of the seal, the blubber or fat of the whale, fish and train oil."

"Yes; all these substances contain a great amount of fat. The natives of these regions, in times of scarcity, have been known to eat their bedding, which is mostly of sealskin. It does not matter what kind of food is presented to them, if it does but contain plenty of fat or carbon."

"Such being the case," said Emily, "it matters not how cold the weather is, if we can but get plenty of food; the cold itself assists us, as it were, to endure it."

"It is so. Such is the wise provision of the Creator for his creatures."

"Another thing worthy of remark is, this food

which is so palatable to the Greenlander and Esquimaux is there found in the greatest abundance. Vegetables to them, as an article of food, would be of no real use, and we find that the climate will support but very few. We will now look at the natives of the torrid zone, and see how they are adapted for the climate in which they live. In the first place what is their food? Would they eat with a relish a piece of seal's-flesh swimming in oil? No, it would kill them. Then we must look for something which has not so much carbon in it. As the air, through the heat of the sun, is so rare, and they take in so little oxygen, we shall find that a diet in which there is but little carbon will suit them much better. Just such we find it; rice, vegetables and fruits, are the chief food of the people in the warmer regions of the globe; and we find it is this produce which is most luxuriant in these warm regions of the globe."

"I understand now," said Edwin, "how it is that man is a creature of all climates. It depends upon the air he breathes, and the food he eats, as well as the clothes he wears."

"Your reasoning, Edwin, is quite correct, and I am glad to hear that you are arriving at such just conclusions."

CHAPTER XVIII.

AIR A VEHICLE OF VAPOUR.

Evaporation—Vapour—What becomes of the vapour when it ascends into the air—The way in which clouds are formed—What are clouds?—Fogs—The melting of fogs—Why horses when hard driven appear to steam in winter, and not in summer—The use of perspiration—Mist—Its causes—Why it does not fall upon rocks, roads, and garden paths—How rain is formed—Why hail seldom falls in winter—How snow is formed—Why we never have snow in summer—Why the atmosphere is fuller of clouds in winter than in summer—Why the atmosphere is mostly clear in frosty weather—The reason that showers mostly come from the south-west—Why the wind blows for three-fourths of the year from the south-west—The trade winds—How vapour is carried from the equator to the poles—Why is it cold when the wind is in the north?—Why we get deep snows in winter from the north-east—Warm winds from the south, and storms from the west.

"WE have seen, in our last two conversations, the use of the air in a mechanical and chemical point of view, and how essential it is to the wants of every creature. Now I wish to call your attention to another use of the air, namely, its being a vehicle of vapour, which it carries from one part of the earth's surface to another; but before I enter upon the subject, it will be necessary to know something about evaporation."

"What is the meaning," said Edwin, "of evaporation."

"It means the act of converting or turning fluids into vapour."

"What is vapour?" said Emily.

"The natural heat of water is about 42 degrees, and whenever its temperature is raised above that point, it slowly turns into a thin invisible gas, which is sometimes called steam, or when it is perceptible we call it vapour. If you place a pan of water in the sun, it is dried up in a very short time; that is, the heat of the sun has turned it into vapour."

"How is this process carried on?" said Edwin.

"By the sun shining upon the water, and warming the particles of water on the surface, the particles which are acted upon expand and become lighter than the air, and consequently ascend into the higher regions where the air is more rare."

"What becomes of the vapour when it has ascended into the air?" said Emily.

"The higher we ascend into the air the colder it gets; and when the vapour gets a certain height the cold air absorbs the heat from the vapour, and thus the vapour is again converted into watery matter, which is even then lighter than the air. These particles of watery matter are driven about in the atmosphere, causing them to strike against each other; and when that takes place they unite and form small flaky-like substances, something of the appearance of snow, but much finer; they are con-

tinually driven about, and when a large quantity of them are collected together, it is called a cloud."

"Is that the way clouds are formed?" said Edwin.

"It is."

"How are they supported in the air?"

"By the heat of the sun, which causes them to rise, and because they are lighter than the air."

"Then the clouds are nothing more than fogs high up in the air."

"No; but we do not call them fogs, only when they touch the ground."

"When it is foggy weather, we are actually among the clouds," said Edwin.

"Yes; it is a curious sight, and which I have often seen when in the open fields, to see one of these fogs melt into vapour. This is very common about September. In the morning, from six o'clock to nine or half-past, a heavy fog will lie upon the fields; as soon as the sun begins to have a power, the fog gradually melts into vapour, breaking into great masses, which gradually float upwards, and quickly disappear, and not a trace of it is left."

"What is the cause of fogs often drawing along the ground, as it were?"

"That generally happens in the autumn or winter, when the sun has but little power, and consequently has not sufficient warmth to melt the particles of which it is composed into vapour?"

"I have often heard that fogs are more dense in London than in the country?"

"Yes; much more so. In a large city like London, when the streets get full and there is no wind, it cannot escape; and the consequence is that it keeps increasing till a breeze springs up and drives it away."

"I have often seen," said Edwin, "in winter, that, when horses have been driven fastly, when they stop they are all of a smoke, as it were. I never could understand why they should do so in winter and not in summer."

"I will tell you. In winter, when a horse perspires, the heat of the body converts the perspiration into vapour, and the cold air turns it into what we call steam. In summer, when the weather is warm, the vapour goes off invisible, because the air is not cold enough to condense it."

"Is that not a very remarkable circumstance?"

"In what way do you mean?"

"In this way: when a horse is very warm, and perspires very much, as the vapour goes away does it not take a great amount of heat from the animal?"

"It does. In fact, it is the moisture or sweat of the horse that carries away the heat. I do not know whether you have ever noticed the fact; but if you have been running, and sweating very much, as soon as the perspiration is gone, you do not feel the inconvenience of the heat any longer, for the simple reason that as the perspiration disappeared it took the heat of your body with it."

"When I have been coming from school on a winter's afternoon, I have often noticed the steam issue from my mouth and nose every time I breathe. What causes that?"

"The same as causes the horse to steam. In summer you do not perceive the vapour, because the air is not cold enough to condense it into steam; but in winter, when the air is cold, the vapour from your nostrils condenses, and that is why you see it."

"What is mist?" said Emily.

"Watery vapour, of a finer form than fog. You may generally see it on a summer's evening, after a very warm day, particularly over damp meadows."

"I have often seen it, but never could understand the *cause*," said Edwin.

"I will explain it to you."

"During the day the sun has been shining very warm, and consequently evaporation has been going on very rapidly, and the earth has got heated. When the sun goes down, and the air begins to cool, the vapour which was evaporated from the earth gets condensed, and it is then we perceive it gently falling down to the earth."

"What is the cause of that?"

"You may see it sometimes resting five or six feet above the ground, and, if you notice it, it gradually descends. The reason is, the air near the surface of the earth is too warm to allow it to descend—that is, the heat of the earth causes it to turn into steam again; but as the heat of the ground decreases, it falls lower and lower till it touches the

earth, and in a very short time the grass is damp with what we call *dew*."

"I have often observed, when I have been in the garden early in the morning, that all the shrubs and plants have been covered with dew, while the gravel path has been quite dry. How can we account for that?"

"As soon as the sun is gone, the plants soon give out their heat, and the dew or vapour can fall upon them; but the gravel path attracts much more heat than plants, consequently it is longer in giving it out. Thus you see the dew, when it falls near the path, is again turned into vapour. Here is a most remarkable circumstance. The dew would not be of any use on the gravel path, high road, or barren rocks, and the result is it does not fall there, but simply where it is most wanted—on plants."

"How is rain formed, papa?"

"To answer that purpose we must again revert to the clouds. I told you they were large masses of vapour, driven about by the air. Now, as they are blown along, they strike against each other; in this manner they form small drops, which keep enlarging till the sun and the air can no longer support them, and they fall, collecting, as they descend, the moisture with which they meet in the air. There is one thing worthy of notice in the falling of rain, and that is the lightness with which it falls; although it often falls from the height of a mile, yet so lightly does it fall that not a leaf is injured."

"If it falls so far I should have thought it would would have cut the leaves to pieces."

"So it would if it was not for the air, which breaks its fall. Even in this little fact we may see design, yet how little do we notice these things. Well might the royal psalmist exclaim :—'How wonderful are Thy ways, O Lord of Hosts!'"

"What is hail, papa?" said Emily.

"Hail is frozen rain. There are several different opinions with regard to the formation of hail; and, as far as I can learn, none of them are very clear upon the subject. It is well known that the higher we ascend the colder it gets. Now these drops of rain must have been formed higher than the freezing point, and in falling through a current of cold air have been frozen. It is remarkable that they seldom fall except during hot weather, and often the hotter the weather is the larger the hailstones."

"How is that accounted for?" said Edwin; "and I have often noticed how cool the air generally is after a hailstorm."

"The only way in which it can be accounted for, is in summer the clouds from which the hail and rain proceed are much higher, and therefore as the drops of rain have such a great distance to fall, they collect a larger amount of moisture in their descent than if they had only a short distance to descend. If it so happens that these large drops of rain get driven by the winds into cold regions of the atmosphere and get frozen, then of course the hailstones are large.

"The latter part of your question is easily solved. Hailstones, you must understand, are drops of water deprived of their heat; and therefore, as soon as they touch the ground, they begin to absorb the heat from the atmosphere, which in a very short time is sensibly cooler. Thus you see when hail is most wanted it falls in the greatest abundance."

"Why is it that hail seldom falls in winter?"

"Because the heat of the sun is not sufficient to cause the vapour to ascend into those regions of cold where the rain gets frozen."

"Can you tell us, papa, how snow is formed?"

"That, too, is formed in the upper regions of the atmosphere. When the vapour is being driven along, it gets into regions where it is condensed and frozen; these little frozen particles are driven along by the winds, and when they touch each other they unite; they still increase as they are driven about, till at last the snowflake is formed."

"How is it that we never have snow in summer?"

"Because, as snow is formed in the air, it gets melted before it reaches the ground. I once had some conversation with a gentleman who was in the habit of ascending in a balloon; and he said that it was no uncommon thing to meet with snow, and on one occasion his car and balloon was covered with it, although the weather was very hot on the ground."

"How is it, said Emily, that in winter the atmosphere is so cloudy and foggy to what it is in summer?"

"The reason that the atmosphere is so full of moisture in the winter, is that the sun does not give sufficient heat to convert the moisture in the atmosphere to vapour."

"I have often observed, said Emily, that nearly always in winter, when the atmosphere is clear, we get a frost, and whenever the sky clears it is nearly always colder; how do you account for that?"

"In winter, when there is a great amount of moisture in the air, and the sky begins to clear, we at once perceive it is much colder. The reason for sky clearing is because the vapour in the air is freezing, and thus the atmosphere is more transparent."

"I have often observed, said Edwin, that showers and storms nearly always come from the south-west, and that the wind blows from that quarter for three parts of the year. I never could understand the reason of that?"

"You have started a rather difficult question, Edwin; but I think I can make you understand it. In the first place you must understand that the world is round, and that it turns upon its axis, and that the equator is hotter than any other part of the globe."

"Yes, papa, we understand that," said Emily.

"Well, if you can understand that our difficulty will not, I trust, be so very great. Now let us suppose that we are at or near the equator; we shall find the sun shining very warm, and the air would be very rare, and consequently would be always

ascending into the higher regions, and the dense or cold air would always be running in one continuous stream; this stream is called the trade winds. Now, Edwin, in what direction do you suppose these winds would come?"

"I should think, by looking at the globe, that they would come from the north and south."

"They would, if the earth was at rest; but you know that it is not at rest, but turns rapidly to the east from the west. But I do not see why that would alter the course of the trade winds?"

I will explain it to you. We must bear in mind that the earth is turning round, and, if you examine this globe as I turn it round, you will see that it rotates at a much greater rate at the equator than at the poles. Now the place from whence the trade winds commence their journey towards the equator does not rotate so fast as when the stream of air gets nearer the equator; and, as the force which they had given to them at starting was not sufficient to cause them to rotate with the earth, were it turned more rapidly, therefore they are left behind, and, instead of coming from the north, they appear to come from the north-east."

"I think I understand you so far, said Edwin; but what becomes of these winds when they get to the equator?"

"They get warmed, and ascend and return back to the north by an upward current. Now, just the reverse happens when they return from the equator, where the earth rotates much more rapidly than

nearer the poles; but the force that the earth gives them at starting causes them to move with a greater rapidity than the earth, and the result is, the wind appears to come from the south-west instead of the south, which it would do if the earth was at rest."

"I think I shall be able to understand it, papa," said Edwin, "with a little thinking; but I did not think it had been so difficult to understand."

"Then I suppose," said Emily, "it is the winds which bring the showers with them, and that is the cause why most of the rain comes from that quarter?"

"It is; and that is why the western part of England is more humid than the eastern. This is a most wonderful provision of the Creator's. If the earth was at rest, and the trade winds came direct from the north, would they have a greater or less amount of space to travel over than if they came from the north-east?"

"They would have the greatest distance to travel by coming from the north-east."

"They would, and consequently they cool a much greater extent of the globe than if they came direct from the north. When these winds get rarified, and take their flight back towards the north, they are not allowed to go empty; but they have to collect all that vast amount of moisture that is evaporated at these warm regions of the globe, and carry it back in the shape of clouds to the colder regions, where there is not so much evaporation.

"When the winds return they do not go direct

towards the north, but in a south-westerly direction. In this way they traverse as much of the globe as it is possible, collecting the moisture, as I before said, and carrying it back to the northern regions, to make up for the loss that they are constantly sustaining by the great ocean currents."

"I have read of the ocean currents, and have often wondered what was their cause. I suppose that they are caused chiefly by the great evaporation that is constantly going on at the equator?"

"You are right, Edwin; evaporation is the primary cause, and, wonderful as it may appear, every drop of water that flows in these currents is taken back by the atmosphere in the form of vapour."

"There is a saying that all rivers flow into the sea, and yet the sea is not full?"

"You are right; and the cause of it is, the water from the ocean is continually being carried away by evaporation. Thus you see there are always streams of cold air and cold water continually flowing towards the equator."

"If such were not the case, the earth at the equator would become so heated, that it would be uninhabitable; but, instead of that, how wisely and beautifully the laws are formed to cool and render it fruitful, and the abode of thousands of happy creatures."

"I think you now understand pretty clearly if it were not for the air there would be nothing to convey the moisture from one part of the globe to another."

"Does it not seem a wonderful fact," said Emily, "that in all probability the showers that water our gardens have been brought from the equator for that purpose?"

"Such, my children, is the fact, and thus the great round of nature keeps going on."

"I have," said Edwin, "heard people say, that when the wind has turned towards the north in winter, we are sure of cold weather. Why should it be cold when the wind blows from the north?"

"Because the winds come from a cold region, and often bear with them clouds laden with snow, which attracts the heat from the air, and renders it cold. If the wind lies to the north-east, we generally get deep snows; in fact, I never remember one deep snow but came from that quarter."

"How do you account for that?"

"If you examine a map of Europe, you will see that the winds which blow from the north-east must cross the frozen plains of Russia; thus, when the wind reaches our shores, it is deprived of nearly all its heat. It is that which renders easterly winds so very cold and cutting. Owing to the extreme cold of these winds, they carry with them great quantities of snow."

"I have often observed that when the wind in winter changes from the north-east to the west, or south-west, it is sure to be warmer?"

"Yes; the winds that come from the south come from warm regions, and those from the west have to cross the Atlantic, and are, therefore, warmer than those that have to traverse large distances overland."

CHAPTER XIX.

WATER.

Its general properties—Non-elastic—Lateral pressure—The taste of water—Ice—Why ice is lighter than water—The cause of water expanding when frozen—The advantage ot its expanding—Why water freezes near the banks of ponds first—Why springs and rivers appear to steam on a frosty morning—The reason of rocks, chalk, earth, &c., crumbling to pieces after a frost—Why some rocks and stones are not affected by frost—The cause of water-pipes bursting in winter—Why some objects will swim in water when others will not—Specific gravity—How to find the specific gravity of a body—Why iron boats and ships float upon the water—Why doors and windows are often difficult to open and shut.

"PAPA, you have not told us about water, and I have a great number of questions to ask about it?"

"And so have I," said Emily. "Water is such a common thing, I almost wonder we had not thought of that first."

"I shall feel most happy in giving you all the information I can respecting this invaluable fluid."

"What are its general properties, papa?" said Edwin.

"Water has weight. It exerts a pressure in all directions equal to the pressure downwards. It is non-elastic. It turns solid at 32 degrees of heat,

and turns into vapour at 212 degrees. It is colourless and tasteless."

"What is meant by non-elastic, papa?" said Edwin.

"In our conversation on air, I showed you that air could be pressed into a space smaller than that which it usually occupies. Wáter cannot be compressed. The space which it naturally occupies it occupies under almost any pressure that can be put upon it."

"I remember," said Edwin, "bursting my water-squirt, by stopping the nozel, and then striking the piston with a hammer. I thought the water would have driven back the piston in the same manner as the air in my popgun did; but instead of that the squirt burst in two places."

"Then I presume that you won't forget that water is incompressible?"

"I have often heard," said Edwin, "of lateral pressure. What is the meaning of the term?"

"It means the pressure which water exercises against the sides of the vessel which contain it. There are many curious experiments with which we might show the properties of water; but, as that is not our particular object at present, we shall omit them till another opportunity."

"There are two things you mentioned, papa, as the properties of water, which do not require any experiment."

"What are they, Emily?"

"Its being without colour or taste."

"Yes; the fact of its being without taste is a very remarkable property, and again shows us the wisdom of the Creator. If water had a taste, no matter how sweet or agreeable it might be to the palate, it would soon cause us to feel a dislike to it. Now, when we feel thirsty, it is always pleasant to us, and when we have drank as much as nature requires we can take no more without a violent effort. If a flavour had been given to it suiting our palates, we should often drink more than we really wanted; while perhaps that peculiar flavour, which was so agreeable to us, would be disagreeable to others. Through this wise arrangement of Providence in not giving it a flavour, it is agreeable to the tastes and wants of the whole animal creation. In this we cannot fail to see how strikingly manifest is the wisdom of the Creator, in adapting things to each other. Even the fact of water being palatable to all creatures is enough to show that there is design in it. I do not hesitate to say that not one artificial beverage can be found that is palatable to the whole of the animal world."

"What is ice, papa?" said Edwin.

"Ice is water deprived of a part of its latent heat. When the heat of the water is abstracted by the cold air down to 32 degrees, it then turns solid, and we then call it ice."

"I have heard you say, papa, that all substances expand by heat, and contract when deprived of it:

if such is the fact, ice ought to be heavier than water."

"You are quite right in the first part of your assertion, and, at the first glance, ice seems to be heavier than water, but water is an exception to this rule. The natural heat of water is about 42 degrees; when it is heated beyond this, it gradually expands, and if the whole body of water in a vessel could be raised instantaneously to 212 degrees, it would instantly change into vapour or steam, but when the heat is reduced down to 32 degrees, it freezes, and as it freezes it expands, and thus it is lighter than the water."

"What causes it to expand?"

"It is thought that when water is frozen it is crystallized, and crystals take up more room than the round particles of which water is composed?

"It seems remarkable," said Edwin, "that water should be an exception to the general rule."

"It is remarkable; but even this was not without design."

"In what way, papa?"

"Let us suppose that as soon as ice was formed it sunk to the bottom, as it would if it were heavier than water; and, as water is a slow conductor of heat, if the pond or lake were deep it would lie for months before it could be melted, and perhaps it would never be able to melt; but you see the fact of its being lighter than the water causes it to float on the surface, where it is again exposed to the sun

and air, and is thus easily reduced to water again."

"I remember," said Emily, "as Edwin and I were coming across the common, one frosty evening, we saw a pool of water just beginning to freeze, and I remember it began on the outside first. What was the reason of that?"

"We have said that water is a slow conductor of heat; it takes it in slowly, and it gives it out the same; therefore the bank, or the earth next the water, gave out its heat before the water, or was reduced first to freezing point. Thus the particles of water nearest the bank freeze first, and the ice gradually extends across the pond."

"I never saw the mill-stream frozen," said Edwin, "but many times the pond against the church; how can that be accounted for?"

"The pond is quite still, and those particles of water which lie upon the top are soon deprived of their heat, and are converted into ice; while in a running stream none of the particles are at rest, but fresh particles are continually coming to the surface; thus, before they can be deprived of their heat, they are forced from the surface, and others supply their places. Another thing: the mill-stream is constantly being fed by several springs a few hundred yards above the mill, so that there is a constant stream of warm water running into it."

"I have seen the river appear to smoke on a frosty morning. What is the cause of that?"

"The reason is this: when the water first comes

out of the earth in frosty weather it is warmer than the atmosphere, in fact it is above 42 degrees of heat, and while in that state it throws off vapour, which, in summer-time, would be invisible; but, owing to the cold air, it is condensed as soon as it rises out of the water, and has the appearance of steam."

"What is the cause of earth, chalk, and rocks, crumbling to pieces after a frost?"

"The substances which you have mentioned all contain water; that is, they have particles of water in every part of them, which get frozen, and, as we have just been saying, water expands when it is frozen,—thus they cause numberless little rents and cracks, and when the frost ceases and the particles of ice are again converted into water, which again contracts to its usual space, the rocks, &c., then fall to pieces, because they have been split by the ice.

"You may often see this illustrated in the cuttings of railroads, particularly in soft hills. Chalk is very much affected by the frost."

"Some stones are not affected by the frost, as granite and marble."

"You are right; it is simply because they do not contain sufficient moisture."

"I suppose," said Emily, "that it was the expansion of which we have been speaking that caused our water pipes to burst last winter?"

"It was."

"How is it, papa," said Edwin, "that some things will swim in the water, and others will not?

If I throw a pin into the water it sinks immediately, but if I throw in a block of wood it swims. Will you be kind enough to explain how that is?"

"Your question depends upon what is called specific gravity. If you take a cubic foot of wood and a cubic foot of water, you will find on weighing the two the water will be the heaviest; that is to say, water is heavier than wood bulk for bulk, and all substances which are lighter than water will swim, while those which are heavier will sink. If you take a cubic foot of iron and a cubic foot of water, you will find that the iron is more than seven times heavier than the water, and all substances which are heavier than an equal amount of water will sink."

"Then I suppose we may take it as a rule that all substances which swim on water are lighter than a quantity of water of their bulk, and all substances that sink are heavier."

"Yes; I will give you a list of the specific gravities of some of the common objects, as it may be of use to you for a reference another day."

TABLE OF SPECIFIC GRAVITIES.

Distilled Water	1·000	Brass	8·396
Sea Water	1·026	Copper	7·988
Platina	20·000	Iron (bar)	7·788
Gold	17·486	Iron (cast)	7·607
Quicksilver	15·568	Zinc	7·191
Lead	11·352	Flint Glass	3·290
Silver	10·391	Marble	2·700

Ivory	1·825	Maple	·754
Coal	1·250	Elm	·600
Oil	·940	Fir	·550
Oak	·931	Cork	·240
Ash	·800		

"How is the specific gravity of a body found?" said Edwin.

"The common way of doing it is, first to weigh the object in air, and then in water, where it will weigh less; find the difference, and divide the weight in air by it. I will give you an illustration: suppose you take this piece of silver, which weighs 159 grains in the air; now we will weigh it in the water, and we shall find that it weighs only 144 grains; therefore it has lost 15 grains. Now we shall have to divide 159 (the weight in the air) by 15, and we shall find the answer about $10\frac{1}{4}$, which is the specific gravity of silver."

"Are we to understand that the silver weighs $10\frac{1}{4}$ times more than a quantity of water equal to its size?"

"Yes."

"I think I understand the subject so far; but I cannot understand how iron boats and ships are made to float on water?"

"Iron ships are now getting more common than wooden ones; in fact nearly all steam vessels are now built of iron. The principle is easy enough to understand. You see this pan, which is of iron. I put it into the water, and it swims. The reason is

this: You see the edges are turned up about an inch; therefore, before it sinks it must displace nearly as much water as it will hold. That is, before it will sink it must displace a weight of water equal to the weight of the quantity which it will hold. It is the same with iron ships; they must displace a weight of water nearly equal to the weight of the quantity which they would contain."

"Is that the way they find the tonnage of vessels?"

"I will give you an illustration. Let us suppose a vessel capable of carrying two hundred tons; she must displace (if she is built of iron) between two and three hundred tons of water; but if she was built of wood, she would be able to carry a heavier weight, because the specific gravity of wood is less than water."

"I never could understand before how iron could be made to swim," said Edwin.

"Do you remember our feat, Edwin, with the brewing tub?" said Emily.

"How was that, Emily?"

"Well, papa, it was very silly of us. One of the tubs was put into the pond, and Edwin said he would have a ride in it; so he got in, and it did not sink near half-way down into the water; and you know, as there was no danger, he persuaded me to get in also. We rode about for a little while, and Edwin would have the gardener's little boy get in. Just as he got in the water began to flow over the

top, and it was full in a minute, and there we were up to our middle in water."

"Now I hope you will be able to tell me why the tub sank with three of you in it?"

"Yes, papa, it was because we three weighed more than the water which the tub would contain."

"I hope you have learned something by your disaster."

"I have often seen the gardener, when he is going to use the wooden tubs, put them in water the night before. Why does he do that?"

"All porous substances, in their natural state, contain more or less moisture, and when vessels have been placed in a dry atmosphere this moisture is absorbed, consequently the wood is said to shrink; but, as soon as they are placed in water, the wood again absorbs moisture, which causes the wood to swell, and thus to keep the liquor from escaping."

"Is that the cause why doors and windows are so difficult to shut?" said Emily.

"It is. In damp weather the wood absorbs moisture and swells, and thus the difficulty of which you speak."

CHAPTER XX.

ANIMAL LIFE.

Of what is an animal composed—Young animals: their growth: proper proportions—The wisdom displayed in the growth of an animal—Hunger—Thirst—Preservation—Fear—Pain—Its Uses—The adaptation of animals to the state in which they live—The peculiarities of a swan—The owl—Its beautiful adaptation to the life it leads—Its eyes.

"Papa, as were going down the path to-day that leads to the river, we saw a dead animal all covered with flies and insects, and neither Edwin nor I could tell why it was so. Will you be kind enough to tell me a little about the decay of animals?

"With pleasure. In fact, it was one of those subjects that I intended to bring under your notice, even if you had not mentioned it. The decay of animal matter is a most wonderful work, and fills the mind with astonishment when we reflect upon it. Before we speak of the decomposition of animal matter, we will first see of what an animal is composed, and we shall find that wonderful compound, which we call an animal, is made up with about eight substances."

"What are those substances, papa?" said Edwin.

"Oxygen, hydrogen, carbon, nitrogen, lime, salt,

a small quantity of ammonia, and phosphorus. It seems a most wonderful fact, that every living creature upon the earth's surface, from the smallest animal to the largest whale that swims the deep, are chemical combinations of these few elements."

"Is it the same, papa, in both young and old animals?"

"Yes; if we take an animal in its earliest stage of existence we shall find that Nature has given it nearly the same elements which are to be found in the parent animal. As the creature advances in age, Nature has so arranged it, that every hour it lives, up to a certain age, keeps adding to every part of the creature. Not a little wisdom is displayed in the fact that all parts grow, or elements are added to the animal in their proper proportion; just enough, and no more. The bones take just sufficient lime and carbon to harden and strengthen them, and keep them in the right proportion with the rest. The limbs, head, and other parts, are likewise administered to in the same manner. Not an atom too much or too little is added to either, but just sufficient is added to keep the animal in its proper proportions. The animal has no power whatever to alter these arrangements. It cannot add or take from of its own accord. Then whence the wisdom that planned this wonderful chemical combination? The most unthinking must at once see that those laws which produce such wonderful results must have had a divine origin. What are man's inven-

tions compared to such as these? Man, with all his boasted powers, can only work upon those laws which God has planned and made ready for him. Man can by a combination of matter make a machine, which soon wears out: animals, which are God's work, have not only the power in themselves to keep in motion and activity, but they have the power of propagating their species, and thus producing others of the same nature. Then again, an animal has laws given it for its own preservation. When it is hungry it feels pain, and hence the desire for food, which, if not complied with, the pain increases till it urges the animal to take food. When moisture is wanted an unpleasant sensation is felt, which keeps on increasing till the animal supplies the want. Another most curious arrangement is the care which an animal takes of itself in case of danger. Nearly all animals at the approach of danger will get out of the way; but if it cannot get away it will turn and fight. In nearly all animals is implanted the idea of fear. Another thing which may cause animals to protect themselves from injury is, if they are struck, or otherwise injured, they feel an unpleasant sensation which we call pain. No doubt the animal takes care of itself to avoid pain. Another curious fact is, that those nerves which are the most sensible of pain lie just under the skin. Thus, if it was not for pain, we should often injure our bodies and not know it: thus you see that, whenever anything is wrong with the body,

it causes pain to the animal, and warns it that something is wrong."

"Do you think, papa, that we do not injure ourselves, not so much from the fear of doing so, as from the pain we shall suffer?"

"I do. If I were to tell you to stick the point of your knife into your hand you would hesitate to do so: why?"

"Because it would hurt me."

"Exactly; you would not do it because you are afraid of the pain which would ensue. Then what is it that protects you from injuring yourself?"

"Pain."

"Certainly. I have heard doctors say that when it has been necessary to amputate a diseased limb, when the patient has been told that the operation is necessary, in nine cases out of ten they have asked if it would be very painful. Thus, you see, were it not for pain we should have no protection to keep us from harm."

"I have often noticed," said Edwin, "how wonderfully animals are adapted for the condition or state of life in which they are to pass their lives."

"You are right, Edwin; nothing more clearly shows the wisdom of the Creator than the adaptation of animals. Did you ever notice a swan, how beautifully it is adapted for the element in which it is to pass its life?"

"I do not know that I have particularly observed it; but is there anything peculiar about it?"

"Do you know what the food of a swan is?"

"I should suppose small fish, frogs, and other things found in the water."

"You are right; and, as the water which they frequent is often of considerable depth, nature has given it a long flexible neck, which it can expand from two feet in length to four, or four feet and a half. Now on the top of this beautiful neck is placed a head; not a big heavy mass of matter which would have weighed it down, but a small, light, and beautiful head, which the bird can easily and gracefully carry. How was it that a head as large as a pig's or a horse's had not been given to it? Simply because nature gives to all animals just those proportions that are necessary for their happiness and condition in life. Then look at its bill; you see it is just adapted for the purpose for which it is wanted—groping in the mud for insects, worms, &c. If it had got a short strong beak, like a hen, the bird would perish for want, as it would be unable to procure its food."

"Then, papa, look at its eyes; they are not placed in front of its head as ours are?"

"No, my son; and even in the placing of its eyes we cannot fail to see design."

"In what way?" said Emily.

"When the swan is swimming in the water, where it is most likely that danger would appear?"

"On the banks of the river?"

"Yes, it might appear on either side at the same

time; and if you notice the eyes of a swan, or other water fowl, you will find the eyes so placed in its head that it can see without any inconvenience both banks at the same time. If it apprehends danger from any other quarter, it has only to turn its head, and it can see both before and behind at the same time. Thus you see how beautifully nature has provided it with means for its preservation. Another curious peculiarity about the swan is,—if there is danger to be apprehended, and it cannot get away with sufficient speed, it has the power of raising its wings into such a form as to form two sails; thus, if the wind is blowing it can swim with much greater rapidity."

"I saw a large white owl last night, papa, sitting on a tree near a large wheat stack. I have read that these birds seldom appear in the day, unless disturbed. How do you account for it?"

"There is another curious fact in nature. Can you tell me what the owl feeds upon?"

"I have read mice."

"You are right; and when do mice come out of their holes?"

"In the evening; we seldom see them at any other time."

"You are right; and, as mice only feed in the evening and early morning, the owl's eyes are so adapted that it can see very well in the faintest twilight."

"I never could understand how that is?"

"If you look at a rabbit's eyes, which are very much like an owl's, you will see that they are very large and round, and collect all the rays of light that falls upon them, which enables them to see very well, even when to us it is nearly dark."

"Why is it, papa, that they are unable to see in the day?"

"Simply because their eyes are dazzled with the light, so that they cannot see. In these facts we can see design. If the eyes of the owl had been such as were only adapted for daylight, it must have perished for the want of food, as it could not see to catch its prey in the dark."

CHAPTER XXI.

DECAY.

Decomposition—Its wonders—The elements prey upon each other—Gas generated—Its uses in decomposition—Carbonic acid—Attraction of birds and insects to dead animals—The flesh fly—The voracity of maggots—How they are preserved—Wasps—Birds—The bones—Their composition—Oxygen the great builder and destroyer of animal and vegetable substances.

"We shall this evening relate a few facts on the subject of decay, or decomposition."

"What is meant, papa, by decomposition?"

"We have another word in the language which will answer our purpose equally as well, and that is rotting. If we say a thing is rotting, it is then in a state of decomposition. It is a most wonderful fact, and fills the mind of thinking persons with astonishment, that no sooner does an animal or vegetable cease to exist, but all the elements of which it is composed seem at once to begin to prey upon it. Let us suppose that an animal has gone through the course of its existence; and wonderful is the process which then takes place."

"I often wonder, papa, what death is," said Emily.

"Death to animals is the stopping of the vital

system. Some part gets worn, or out of its proper place, some stoppage takes place, and thus the whole system stops, and we say the animal is dead. No sooner is the animal dead, than, as if these elements seemed to know that their presence is no longer needed, and it is their duty to haste away as soon as possible, they enter into some new forms and shapes."

"Can you tell us, papa, how that is?"

"As soon as life is gone, the gastric juices that are found in the stomach and intestines, as if out of wantonness, begin to pull to pieces what they have for years been building up. These juices immediately begin to prey upon the stomach and intestines, forming, as they proceed, a kind of gas or air, called by chemists carburetted hydrogen, which has a most disagreeable odour."

"Is it that gas which we perceive when animals are decaying?"

"Yes."

"I cannot see the use of that gas, papa, although I have no doubt it is of some use."

"You are right; it is of great use, as I shall show you presently. This gas, as it generates, swells out the body, till at length it bursts, and admits the oxygen of the air, and then the body is soon gone. The oxygen unites with the carbon, and flies away in the shape of carbonic acid; which, as you are aware, goes off to feed the trees, or to form new rocks at the bottom of the ocean. Now this gas, which is

so unpleasant to us, attracts myriads of insects and birds, which prey upon the body as long as it lasts. One of the most important of these flesh-eaters is the larva of the horse-fly."

"I thought that the flesh-fly lived upon flesh," said Edwin.

"No. Its food is fruit, and sweet substances that come in its way."

"Then why are they called flesh-flies?"

"Simply because they deposit their young in the flesh of dead animals, which, if the weather is warm, soon show signs of life, and in a few hours eat their way into the flesh, which serves them both for food and shelter. It is surprising what a vast amount of flesh these maggots can eat. Wishing to ascertain the amount of food that they consumed, I once cut a piece of meat, and put it where no other flies could reach. The piece with the maggots weighed three ounces when I cut it out, and at the end of a week the meat had wasted nearly half-an-ounce, and upon weighing the maggots, I found that they had consumed more than double their own weight.

"What becomes of these maggots when all the flesh is eaten. They cannot fly to another carcase?"

"You are right, and yet they are provided for by the great Creator."

"In what way, papa?"

"As soon as they arrive at full growth, they cease to feed, and fall off the animal, and appear as if they were dead. Their white skin turns brown,

and they fall to the earth and lie hid in the long grass, where they remain till the following summer, when they burst the brown skin that covers them, and come forth a perfect fly."

Are there any other flesh-eaters besides these maggots?"

"Yes, wasps: they will soon carry away large quantities, and destroy a vast quantity of the maggots which surround a dead animal. Birds are attracted by the smell of a dead carcass, and feed upon the maggots. In this way the animal is soon gone; and where is it gone? The carbon, as I before said, goes off in the shape of carbonic acid, and no sooner is it set free than millions of plants are ready to take it in; thus, no sooner has it passed from the animal than it directly passes into new forms, creating new life and animation. When the carbon is set free by the oxygen, the nitrogen and hydrogen are set free at the same time into the atmosphere, and the hydrogen is again transformed into water from whence it came. In a few weeks, the body of the animal, with all its wondrous combinations, and which had been years in building, is gone, and all that we have left is the bones."

"What are bones, papa?" said Edwin.

"Bones are composed of carbon, lime, and phosphorus. If a bone is burnt, the first thing that goes off is the phosphorus, and the carbon and lime are left. If it is then ground into dust, we have what is called lamp-black, or animal charcoal, which

is so extensively used in the manufacture of blacking. Burn the carbon still further, and the oxygen takes away the carbon, and we have a white ash left, which is lime, which must fall to the earth before it can form new elements."

"Oxygen seems to be a great busybody in decomposition," said Edwin.

"It is. It is found everywhere, and seems to be appointed by the Creator to assist in building up and pulling down. A plant could not exist without oxygen carried the carbon to it, neither could a plant or animal decay without it. No sooner is life extinct from an animal, than the oxygen immediately rushes as it were to set the elements free, and bear those elements that cannot travel themselves to new duties. It is a curious fact; but if it were not for oxygen, we could not exist; and if it were not for oxygen, we could not decay when life was extinct. There is not an animal or vegetable but it helps to decompose; every metal except gold is destroyed by it. Take a piece of iron, and lay it in the air, and in a short time its surface is covered with rust; the rust is a combination of iron and oxygen, and called by chemists, oxide of iron. Oxygen is a most useful element, and is found in the greatest abundance, and in every variety of animal and vegetable substances."

CHAPTER XXII.

GRAVITATION.

The meaning of gravitation—Why we are tired when we walk long distances—Why it is more difficult to walk up-hill than along the level ground—The use of gravitation—The scale beam—The water-mill—Why water seeks its level—The pendulum—Capillary attraction—Its uses in nature—Attraction of cohesion—Its uses—Conclusion.

"I HOPE you suffered no inconvenience from your long walk yesterday."

"No, indeed, papa; I never enjoyed anything more in my life. The view from the top of the hill was most delightful."

"Yes, it is a lovely spot, and that is why I wished very much that you should see it."

"But where is Edwin this morning?"

"I am here," said Edwin, entering the room.

"How did you enjoy yourself yesterday? I hope you do not feel tired."

"No papa, not now, thank you; but I was very tired yesterday when I arrived at the top of the hill. Now papa, will you tell me what it was that made me tired when we were ascending the hill?"

"That question involves a new science, which we have not yet touched upon; but, if you will have a little patience, I will explain it to you. It is called the attraction of gravitation."

"What is the meaning of those terms?"

"Attraction means drawing or pulling, and gravitation means weight. That is to say, there is a power exercised between the earth and us, and the result of those two powers is to keep us upon the earth's surface. This power seems to act from the centre of the earth, and therefore every object upon the earth's surface has an inclination to go to that point. It is this inclination that keeps every object upon the face of the earth."

"I feel no power acting upon me that I am aware of," said Edwin.

"Did you not say that you felt tired yesterday?"

"Yes, papa; but I was not aware that it was the power of gravitation that made me tired."

"I will give you a further explanation of this."

"You remember our reading that delightful book called 'Evenings at Home?'"

"Yes, papa; I put it in the library a few days ago. Shall I fetch it?"

"Yes; and we shall find there a better explanation than I am able to give you. You will find it on the 228th page."

"Shall I read it, papa?"

"If you please."

"'Sir Isaac Newton, after deep meditation, discovered that there was a law in nature called attraction, by virtue of which every particle of matter, that is, everything of which the world is composed, draws towards it every other particle of matter, with

a force proportioned to its size and distance. Lay two marbles upon the table. They have a tendency to come together, and they would do so if there were nothing else in the room; but they are also attracted by the table, by the ground, and every thing else in the room, and these different attractions pull against each other. Now the globe or the earth is a prodigious mass of matter, to which nothing near it can bear any comparison. It draws, therefore, with mighty force everything within its reach; which is the cause of everything having a tendency to fall; and this is called the gravitation of bodies, or that which gives them weight. When I lift up anything, I act contrary to this force; for which reason it seems heavy to me, and the heavier the more matter it contains, since that increases the attraction of the earth for it.'"

"Thank you, Emily; you have read it very nicely."

"I think I understand you now, papa," said Edwin; "the earth has a power of attracting every object. If I drop this penny, the reason that it falls to the earth is, there is a mutual attraction between the earth and the penny?"

"You are quite correct."

"I suppose," said Emily, "if there is a mutual attraction between them, the reason of the penny falling to the earth is, the earth has the greatest power of attraction?"

"Yes, the earth is larger than any object that

can be placed upon it, and consequently every object must be attracted by it."

"When Emily was reading, she said, that if two marbles were placed near each other, they would attract each other if there were nothing else to prevent them. How can that be proved?"

"It is a remarkable fact, and one which I have no doubt you have often noticed. In large towns, where there are a great number of high buildings, often in narrow lanes, these buildings often seem as if they had a tendency to come together, in fact such would be the case if they did not put large beams of wood to prevent them."

"Is that because they attract each other?"

"Yes; and it is upon the same principle that the marbles in the room would come together. I remember a very striking instance of this kind taking place between two parallel railway bridges: one bridge had been built about six years, and they were erecting another of brick about four feet distance from it. I told the clerk of the works what was likely to be the result, but he seemed to think very lightly of the matter. The bridge was finished, and the most critical architect could not point out a defect in it. About a week after it was finished, I saw some workmen putting large beams of wood between the two to prevent the catastrophe I had predicted. I hope you now understand what is meant by gravitation?"

"Yes, papa," said Edwin.

"Now we can go back to your question, why you were tired with walking yesterday?"

"As all objects are attracted by the earth, they have all an inclination to remain at rest, and, if not put into motion by their own or some other power, would remain at rest for ever. When we attempt to walk we have this power to overcome, and we must always keep up a force to counteract the one that is striving to bring us to rest, and the keeping up of this force exhausts our strength, and gives us the feeling which we call 'tired.'"

"I have often noticed, and particularly yesterday, that we can always walk better on the level than we can up a hill?"

"Yes, that is very evident; in the first case we have but one power to overcome, but in the second there is a two-fold power to overcome. When you are walking along a level surface, you have only to exert yourself against the power which is striving to bring you to rest; but in the last case you have not only to overcome the power which is bringing you to rest, but also the power which the earth exerts upon you in consequence of your going further from the point of gravitation, namely the centre of the earth."

"I do not think I perfectly understand you," said Edwin. "Do you mean that every step I advance up a hill, I have to lift my body against the power of gravitation?"

"Yes; and that is the cause of the fatigue you felt yesterday."

"You said the other evening, papa, that all the laws of nature were given for good and wise purposes. I do not see the use of this law, which appears to hinder us in every way: we cannot walk, but we feel tired; we cannot work, but we have this power dragging upon us; we cannot run, but it hinders us; in fact I cannot see any good in it at all?"

"What I said, Emily, regarding all laws being sent for a good and wise purpose, I see no reason yet to retract. You speak, my child, without thinking. Let us examine the subject for a few minutes, and I think you will then change your mind. Let us suppose that you had got your wish?"

"Yes; and I could then run about the whole day and not be the least tired."

"Not so fast; I do not think you would be able to run at all: as for jumping you might jump as high as the highest mountain?"

"That would be nice, and how pleasant it would be to come gently down again; and besides, we should not have the trouble of toiling step by step up a long hill, but give a spring, and we should be at the top by the time we could walk ten steps."

"Stop, Emily," said Mr. May. "I told you that you could jump from the earth's surface, but I never said a word about your coming gently down

again; in fact, when you took your leap, you would keep on moving from the earth's surface just as fast as when you started."

"But where should I go, papa?"

"I cannot say; but I suppose you would go on for ever, or till you came in contact with some planet, or comet."

"But why could I not return to the earth's surface?"

"Because you have exerted a power which propels you from it, and you have no power to hinder your flight, and of course no power to bring you back. As for working, there would be no such thing, no man could exert a force sufficient to do anything, a hammer would fall with the same weight as a feather; in fact, no power would be required, a man could carry a steam engine if there were such a thing. There would be no such thing as weight, and a child's hand could lift a rock that now weighs twenty tons. If the law of gravitation were annihilated, all objects would leave the earth's surface, and the earth itself would fly into unknown regions of space. The air we breathe, the waters of the ocean, and every living animal would be hurled into space, and fall to atoms."

"I am surprised at what you say, papa. How foolish it was of me to say what I did! but I said it without thinking."

"Yes, Emily. I know you spoke without thinking, but I hope it will be a lesson for the future."

"Has man," said Edwin, "taken advantage of this law for any of his purposes?"

"Yes, he is obliged to take advantage of it. A mason cannot set up a building without attending to this law. He knows by experience that if its weight was not in the centre of attraction, the earth would pull it to the ground, therefore he has to build it in such a manner that it is not attracted only from the space upon which it stands. The scale beam is also upon this principle; if you notice, it is exactly balanced; and if a pound weight is put at one end, the earth immediately attracts it, and consequently it requires a pound weight at the other end to equal the gravitation of the other. A water mill is upon the same principle. It is the attraction of gravitation that causes water to flow."

"I thought," said Emily, "that it was one of the laws of fluids to find their own level."

"So it is; but gravitation is the cause of the law. The water would be quite content to remain stationary if there were nothing to draw it down the bed of the river. In this fact alone we cannot fail to trace the wonder-working hand of an Almighty Creator. If water was not drawn down the rivers by the influence of gravitation, instead of giving life and vigour to thousands of thirsty animals, it would remain where it first issued from the earth, and for want of it, animals would soon cease to exist."

"I have just thought of another thing," said

Edwin; "which would be useless if it were not for gravitation."

"What is that, Edwin?"

"The clock pendulum."

"You are right, my son, gravitation is one cause of its swinging backwards and forwards. To keep it in motion there is a twofold power. The force which we give the pendulum at starting tends to thrust it out of its perpendicular and attraction strives to pull it back again; but owing to a steel spring and the clock weight, it is forced beyond the point where gravitation is drawing it; thus it is kept in motion as long as both powers are exerted."

"Are there any other kinds of attractions besides the attraction of gravitation."

"Yes, there is capillary attraction, and the attraction of cohesion."

"What is meant, said Emily, "by capillary attraction?"

"It is that power which enables moisture to insinuate itself into all porous substances. Take a sponge which is full of small holes, and drop it into water, in a very short space of time the water will have found its way into every pore of the sponge. That power by which the water ascends is called capillary attraction. If you place a lump of sugar at the bottom of your cup, if there are a few drops of moisture, the sugar will immediately absorb it."

"That reminds me, papa," said Edwin, "of what I once did."

"What was that?"

"When I went to bed, through carelessness I put the towel in the wash-hand basin with part of it hanging over the side."

"What was the result in the morning?"

"The water was all gone over the side of the basin, and was spreading itself about the floor."

"The reason of that was, the water was attracted by the towel, and as soon as it reached the top of the basin, it went over easily enough. That is a good instance of capillary attraction."

"Is capillary attraction of any use in Nature?"

"Yes, if it were not for this law moisture could not ascend the pores of plants, neither would it circulate in the earth; where it fell there it would remain. When we say an object absorbs moisture, we mean that the object is acted upon by capillary attraction."

"What is meant by the attraction of cohesion?"

"It means that power by which objects are held together. All solids are held together by that power, some more closely than others; for instance, granite is held more firmly together than a brick. Were it not for that law the whole globe would be but a mass of dust, the particles of which would be so loose, that they would no more bear our weight than the waters of the ocean. Thus, my children, you see the use of this wonderful law.

"In drawing my remarks to a close, as I intend this to be the last conversation for some time, I have only to say that I hope you have not only gained some useful knowledge; but that you have also become better acquainted with those things around you; that you now see with a clearer eye the great and wonderful works of God by which you are daily surrounded; and that you have been led into a method of observing and gaining information for yourselves. If such be the case, our labour has not been in vain."

THE END.

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